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Volume 44 Fall 2007 Number 2

Creation Research Society Quarterly

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The Orion Nebula (M42) in the constellation Orion with the blue reflection nebula on the back cover. This is a mosaic of 2 images (iStockPhoto.com).

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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

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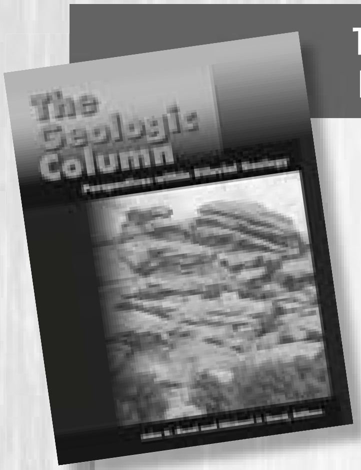
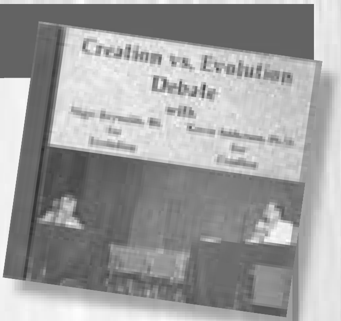


The Geologic Column: Perspectives within Diluvial Geology

John K. Reed and Michael J. Oard, Editors 2006. Creation Research Society, 157 pages. Regular price: $15.00; Member price: $11.00.

Many wonder how the evolutionary/uniformitarian geologic column fits into diluvial geology. At present, there is a remarkable diversity of original thought on this subject. Recent exchanges in the creationist literature show a tendency for various participants to talk past one another. This book has brought these different perspectives together with two goals: 1) to better define the real differences within diluvial geology, and 2) to identify the concrete issues that will provide a basis for continued research and, hopefully, future resolution. The editors went one step further by providing, at the end of most chapters, a forum with comments and responses. In addition to the editors, the other authors are: Terry Mortenson, Peter Klevberg, Carl Froede Jr., David J. Tyler, Harold G. Coffin, and Emil Silvestru. Though it may be difficult to visualize now, diluvial geology represents a major paradigm shift that holds the potential to stimulate a revolution within the earth sciences.

Creation vs. Evolution Debate



2006. Creation Research Society, approx. 45 minutes. Audio CD. Regular price: $10.00; Member price: $8.00.

Dr. Kevin Anderson (director of the Society's Van Andel Creation Research Center) squares off against local Arizona anti-creationist, Nigel Reynolds. The debate features initial arguments by both presenters followed by lively rebuttals, cross-examinations, and audience questions. This debate provides the listener an excellent opportunity to weigh the arguments of each side and seriously consider where the scientific evidence best fits.

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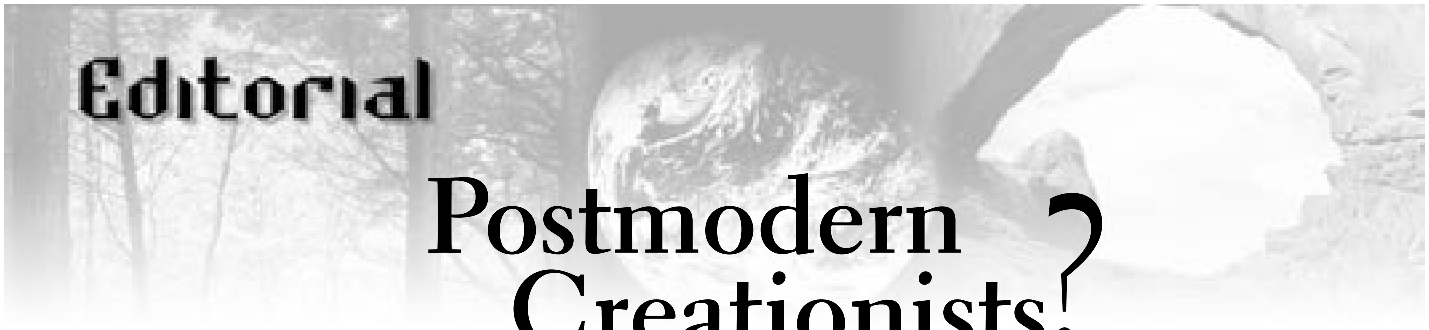

Editorial

Postmodern Creationists?

Specific definitions of postmodernism vary. Even its ardent supporters tend not to agree on its exact meaning or worldview. In a nutshell, the term "postmodernism" refers to a philosophical reaction to "modernism"—i.e., the reliance on modern technology and human understanding to solve all problems. This reaction has generally become a rejection of "modernism" by many adherents of post-modernistic philosophies.

Creationists would tend to agree. Not all problems can be solved by either human understanding or technological advancements. In fact, some of our technological advances create as many problems as they solve. Unfortunately, in a search for purpose and perspective, some postmodernists tended to assume that since humans cannot provide ultimate answers, it must mean there are no ultimate answers. Hence, relativism began to creep into many postmodernist writings.

As such, postmodernism has become the receptacle of relativistic principles, including denial of absolute truth. Once absolute truth is denied, then the very concept of truth becomes uncertain. As Pontius Pilate asked, "What is truth?" If a truth is not absolute, then it must not be totally true or is not always true. It must contain some elements that are not true. Where do these nontrue elements end and truth begin? In the absence of absolute truth, all we are left with is partial truth. But is there really such a thing as "partial truth"? So-called partial truth serves no purpose of informing or engaging in truthful communication since humans often cannot discern the truthful elements from those that are not true. Ultimately, partial truth is really just an untruth, and we are left with a void of truth.

The inability of humans to discern has now led to the philosophy that all truth is merely a matter of one's personal opinion. All truth is relative. Who can really say what is or is not true? Without a clear boundary of truth, then all aspects of human activity become merely personal preference. Who can say that lying is wrong? A "gray" area now exists between what is true and what is not true. Who can say that homosexuality or sexual promiscuity is wrong? In fact, who can say what is right or what is wrong? What is more, who can say that any action is either good or bad?

Regardless of what some postmodernists may or may not claim, the absence of truth leads directly to relativism. It cannot be avoided. And relativism is very compatible with materialism (the philosophy that the material world is all that exists). Richard Dawkins (ardent anticreationist and "high priest" of materialism) claims that there is "no purpose, no evil and no good" in the universe (Dawkins, 1995, p. 85). This statement could have been made by a postmodernist. Ironically, Dawkins is a vocal critic of postmodernism (Dawkins, 1998)—but not for all the right reasons.

If all that exists is the material world, then any guidelines or principles of truth must originate strictly from that material world. There is no moral lawgiver apart from or above the material world. Thus, humans become the final authority on right and wrong. But remember, humans lack the ability to fully discern ultimates. So, we return once again to a relativistic comprehension of truth.

While claiming the two worldviews are distinct, both postmodernists and materialists are seeking to take modern society down the same moral path. It is a path that should concern any Christian. The absence of absolutes, such as good or evil (or even purpose) leads the two groups to the same conclusions.

Does the Bible represent the ultimate, true word of God, or is it impossible for such ultimate truth to exist anywhere?

But, some challenge, supporters of these views still live moral lives, so how can I argue that these philosophies lead to immoral behavior? (Or, should I say, they live *relatively* moral lives—pun certainly intended? Remember, compared to God, we are all immoral: Isa. 64:6.) I would submit that their morality is more a response to social norms (and the "salt" of Christians) than a product of their philosophical worldview. Treating your neighbor with love and respect brings positive reward back to you; hence there is a "natural" tendency to do such. But loving your enemy is not a "natural" response, and neither postmodernism nor materialism teaches this. What is more, it is also consistent within these two philosophies to treat your neighbors with hatred if you feel it serves your best interest to be rid of them. When there is no "ultimate truth," then there is no "ultimate morality." There is no "higher law" of human behavior. Moral decisions become a matter of personal preference (Judg. 17:6).

In view of this, it is a sad trend that such thinking has begun to appear among some who claim to be Christians (and even creationists). Since humans are neither infinite nor all-knowing, it is impossible for a human to pronounce any absolutes. So they reason that there must not be an ultimate or absolute truth. Specifically, the areas being challenged are not only the truth of Genesis (big surprise!) but also the truth of Christ's divinity and God's promise of salvation. It tends to simply boil down to this: Does the Bible (in its original autographs) represent the ultimate, true word of God, or is it impossible for such ultimate truth to exist anywhere?

At a recent Christian convention, I was confronted by a professor from a supposedly "conservative" Christian college. He chastised me (and CRS) for being an embarrassment to the "church" and hindering the "church's" ability to reach the scientific community. His reason: CRS is not mainstream. (Of course, I would assume that he, or at least the doctrine of his college, was not "mainstream" either, but I guess that did not count.) Apparently, he had concluded that the only way to reach the scientific community is to conform. I would challenge that the vast majority of the scientists in CRS would contend that conformist-style arguments rarely engage or attract scientists. This professor was not a scientist; he just seemed to think he knew more of how to deal with scientists than a scientific society.

Even more to the point, he also doubted the importance of whether the Bible is absolutely truth. This is not surprising, and, in fact, such doubts are all too typical of many of our contemporary "conservative" theologians. It does not take much intense thought to see the slippery slope of this type of thinking. If God's promise of salvation through grace is not absolute and final (Eph. 2:8), then it is possible that there will be no salvation through grace. Perhaps Jesus is not the only way (or even *a* way) to salvation (Acts 4:12). In attempts to be more "attractive" to people, the emergent church concept has progressively downplayed Christ and His crucifixion (1 Cor. 2:2). Apparently, this approach desires to cater to people's carnal hearts rather than to God's righteousness (2 Tim. 4:3).

I am reminded of the biblical admonition to not lean on human understanding (Prov. 3:5). Granted, we humans may have difficulty discerning absolute truths, but God, as Creator, certainly can. If He cannot discern absolutes, then He is not what He claims. Instead, He is as undiscerning and unknowing as we are.

As Creator, God becomes the ultimate in the universe—ultimate authority, ultimate power, and ultimate truth. If He is not the ultimate truth, then he is not the Creator. There is no middle ground. He is not sort-of the Creator. He is not sort-of the ultimate power. There can be no equivocation: He is ultimate or He is nothing.

As creationists, we should have no doubt of God's role as both Creator and ultimate authority. As creationists, we worship and serve the Creator rather than the creation (Rom. 1:25). In so doing, we acknowledge our own limits, weaknesses, and failings. How many times do we hear the expression, "nobody's perfect"? This should never be used as an excuse for our sinful behavior or lack of understanding. Rather, it should be a humbling reminder that we are created beings with distinct and numerous limitations. But, the Creator is perfect, with no limitations. He is the ultimate answer to all human problems and questions.

In a recent interview in *Time Magazine* (Nov. 5, 2006), Richard Dawkins attempted to chide theologians and creationists by suggesting that "if there is a God, [He] is going to be a whole lot bigger and a whole lot more incomprehensible than anything that any theologian of any religion has ever proposed." *Yes!* I could not have said it better myself. It is too bad that Dawkins did not fully comprehend what he said. As the ultimate, God the Creator is beyond our comprehension, yet he interacts in our lives in a very personal and comprehensible manner. That is part of what being "Ultimate" is all about.

Kevin Anderson, Ph.D.
Editor
Creation Research Society Quarterly

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Book Review

Is Belief in God Good, Bad or Irrelevant?

Edited by Preston Jones

InterVarsity Press, Downers Grove, IL, 2006, 164 pages, $13.00.

This book consists of reprints of an E-mail give-and-take dialogue between Preston Jones, a professor at a Christian college, and Greg Graffin, head of a popular punk rock band called Bad Religion and an atheist with a Ph.D. A major issue raised in the exchange is evolution, an issue that the dialogue illustrates is central to the whole theistic-atheistic debate.

The dialogue produces much insight into the adverse effects of Darwinism on belief in God. Greg Graffin's Ph.D. is on the religious beliefs of leading evolutionary biologists. The sample he polled consisted of 271 scientists, and he achieved close to a 56 percent return rate (N=151). Graffin found that almost 98.7 percent of his respondents rejected a traditional theistic worldview, but rather were functional atheists if theism is defined as a belief in a personal creative God as taught by the Christian, Jewish, and Islamic religions.

Judge Jones, in the Dover, Pennsylvania Intelligent Design case, ruled that no conflict exists between Darwinism and theism. Graffin's Cornell Ph.D. dissertation (and this book) makes it clear that orthodox neo-Darwinism (of which a central tenet is naturalism) and theism are at opposite ends of the spectrum on all of the major worldview questions. In Graffin's words, "In most evolutionary biologists' view, there is no conflict between evolution and religion on one important condition: that religion is essentially atheistic" (pp. 21-22). As Graffin stresses, his study found that "naturalism is a young, new religion" which is now dominant among leading Darwinists (p. 38). Given the validity of this study, Judge Jones has ruled that one worldview, Darwinism, is now the state religion, and that teaching a theistic worldview in state schools is illegal.

Graffin raises most all of the usual misconceptions and misunderstandings used to denigrate theism, such as the Inquisition (p. 28), Galileo's putative conflicts with the church, and the erroneous belief that the Christian church taught that the earth was flat up to the time of Columbus. Graffin seems determined to allow his ideological prejudice to prevent a careful consideration of the many issues that he raises. He even writes that he avoids reading anything written by "Christian scholars," reasoning that "I am simply not interested in learning how modern knowledge can be reconciled with outdated theology" (p. 25). How can he ever understand reality if he refuses to look at both sides of controversial issues? As is often said, it is dangerous to read only one book about any one topic.

Nonetheless, much good material written by non-Christians exists on the issues Graffin raises. Henry Kamen, a leading Jewish scholar, produced an excellent work titled *The Spanish Inquisition: a Historical Revision*. This book documents the fact that the common version of the Inquisition is wrong. This excellent study effectively refutes Griffin's major claims about the Inquisition. The flat-earth myth has been effectively refuted by Jeffrey Burton Russell in his *Inventing the Flat Earth*. The common Galileo myth also has been well documented as wrong by numerous historians, including Giorgio De Santillann in his *The Crime of Galileo*. Graffin's views on many of the other issues also are unfounded but, unfortunately, are often poorly challenged by Jones. In my judgment, Professor Jones could have done a much better job defending his worldview. Nonetheless, the book provides much insight on this central debate.

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A Review of Stellar Remnants: Physics, Evolution, and Interpretation

Danny R. Faulkner*

Abstract

Astronomers think that stars end their existence as one of three possible stellar remnants. In recent decades, astronomers have amassed a tremendous amount of observational data and theoretical models to support an evolutionary interpretation of stellar remnants. We survey this topic and discuss possible creationary responses to it.

Introduction

Recent issues of this quarterly have contained articles dealing with stellar remnants (Davies, 2007; DeYoung, 2006). In this article, we explore three topics. First, we review the types of stellar remnants recognized in the astronomical field. Second, we briefly describe the observations and physics that support the identification of these objects. Third, we discuss the evolutionary framework that astronomers generally think explains these different objects. In the conclusion we will discuss some of the possible creationary responses to these evolutionary ideas. As creationists, we reject evolutionary explanations and ought to respond to them with criticisms and creationary alternatives. However, in our critique of these evolutionary ideas, we must be very careful that we do not mistakenly "throw the baby out with the bath water" by dismissing some of the conclusions that are based upon good observations and physics. As difficult as it may be, we must separate the evolutionary speculations from the well-established ideas.

Stellar Remnants: Observations and Physics

Modern astronomers usually define a star as a hot, luminous, self-gravitating (roughly) sphere of gas that derives or has in the past derived a significant portion of its luminous energy from thermonuclear fusion. Detailed calculation of the theoretical interior structure of stars reveals that below about 7% of the mass of the sun, a hot sphere of gas lacks sufficient internal temperature to initiate the requisite fusion reactions. Therefore, astronomers recognize this 7% cutoff as the lower limit that a star can have. Over the past two decades or so, astronomers have computed the theoretical structure of gas spheres below this threshold. These calculations reveal that these substellar mass objects derive most of their energy from gravitational contraction (the Kelvin-Helmholtz mechanism), though during some stages they obtain a portion of their energy from nuclear reactions. Astronomers once thought that the Kelvin-Helmholtz mechanism powered the sun and other stars, as some creationists today do. This energy source ought to make these substellar objects appear similar to true stars in luminosity, temperature, and radius. In short, these "brown dwarfs," as astronomers have dubbed them, ought to appear similar to low mass, low luminosity stars. Indeed, in recent years astronomers have claimed discovery of a number of brown dwarfs.

As an interesting aside, astronomers now generally think that brown dwarfs have no clear minimum mass. Instead, with decreasing mass, brown dwarfs gradually morph into cooler objects that ordinarily we would call planets (objects that do not undergo nuclear fusion). This view results in a continuum from high-mass stars, to low-mass stars, to high-mass brown dwarfs, to low-mass brown dwarfs, to high-mass planets, and then to low-mass planets. Since there is no clear distinction between small planets and large asteroids, many astronomers extend the continuum down to very small (microscopic) asteroids. (In the summer of 2006, the International

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Astronomical Union attempted to define the minimum size for a planet, but this definition remains controversial and almost certainly will continue to be refined.) As long as the definition of brown dwarf stars and extrasolar planets remained theoretical constructs, stars and planets remained distinct objects. However, with the recent discovery of brown dwarfs and extrasolar planets within the gap, the distinction between stars and planets is now murky. It is easy to see that there are evolutionary ideas lurking in this, but we will not discuss this issue further at this time.

If the least massive stars must have at least 7% the mass of the sun, is there a maximum mass that a star may have? The answer to this question is less certain. First, low-mass stars are very common, but high-mass stars are very rare, so the statistics for high-mass stars are not as good as the statistics for low-mass stars. Second, there are theoretical problems with extremely high-mass stars. Stars up to 83 (WR 20a) times the mass of the sun are known to exist. With higher mass, stars likely become very unstable, so most astronomers think that the upper limit for the masses of stars is not much less than 100 times that of the sun.

Faulkner and DeYoung (1991) and Briegleb (1993) previously have discussed the Hertzsprung-Russell (HR) diagram in the creation literature. The HR diagram is a plot of some measure of stellar luminosity versus a measure of the stellar temperature. For historical reasons, luminosity increases upward, but temperature increases toward the left. Most stars appear to fall along the main sequence (MS), a roughly diagonal band from upper left to lower right. The hottest and brightest MS stars lie to the upper left, while the coolest and dimmest MS stars lie on the lower right. The most massive and largest MS stars are on the upper end of the MS. Descending the MS, stellar mass and size decrease. We have previously discussed the range in stellar masses; the largest MS stars are nearly 20 times the diameter of the smallest MS stars.

Not all stars lie along the MS. Some stars lie above and to the right of the MS. These stars generally are larger than MS stars, so astronomers call them giant stars. Some of the coolest appear red, so we call them red giants. To the lower left of the main sequence are stars about 1–2% the diameter of the sun, or about 1–2 times the diameter of the earth. We call these stars white dwarfs, because these stars are so small, and the first discovered were white in color. A white star is very hot. Eventually, astronomers found white dwarfs that were cooler, with colors trending toward blue and yellow, but we still call them white dwarfs.

White dwarf stars are common, and we find many in binary star systems. The latter is important, because the study of the orbits of binary stars offers us the only direct way to measure the masses of stars. We find that white dwarf (WD) stars may have as little as half the mass of the sun, but the upper limit is about 1.4 solar masses. Because WD's are so common and many are near us, we have learned much about their structure. For instance, we know the distances to a number of WDs. Knowing the distance, we can calculate a WD's luminosity from its observed brightness. Astronomers have various ways to determine temperatures of stars. They can use the Stefan-Boltzmann law to estimate a WD's size (and hence volume) from its luminosity and temperature. And they can determine the density by dividing the mass by the volume. We find that WDs are very dense—many thousands of times the density of water. This density is several orders of magnitude denser than any substance on earth. Astronomers discovered the first WDs a little more than a century ago. At the time, their high density was a mystery. It was not until the early 1930s that pioneering astrophysicists used then-new quantum mechanics to deduce the structure of WDs.

Hydrostatic equilibrium holds a star together. Hydrostatic equilibrium is the balance between gravity and pressure. Gravity pulls the star's matter toward the center, while pressure pushes the matter outward. Hydrostatic equilibrium is a well-understood principle that explains many phenomena, such as buoyancy. Hydrostatic equilibrium is self-regulating. Suppose that gravity exceeds pressure. Then gravity will shrink a star; but as the star shrinks, its pressure will increase, following the ideal gas law. While the star's gravity will also increase with shrinkage, the pressure increases much more rapidly. Soon, the two forces come back into balance. On the other hand, if pressure exceeds gravity, the star will expand until balance is restored.

The great mystery of WDs a century ago was the question of what held them together. One of the best examples of a WD is the binary companion to Sirius, the brightest star in our sky. Since it was in a binary star, astronomers could determine the mass of Sirius B, as the WD in the system is called. Because Sirius is so close (a little more than eight light years), astronomers also knew how much total radiation that Sirius B emitted. They also could estimate the temperature of Sirius B from its color. The brightness and temperature allow us to determine the WD's size. Newton's law of gravity reveals the surface gravity. From the temperature and density, astronomers could calculate the pressure from the ideal gas law. The gravity was far greater than the computed pressure, which meant that the WD was far out of hydrostatic equilibrium. Absent some unknown pressure, the WD ought to rapidly collapse, but obviously it did not.

What provided this pressure? According to quantum mechanics, electrons cannot be indefinitely compressed. This is because electrons obey the Pauli Exclusion Principle, which forbids degeneracy. Degeneracy exists when more than one particle occupies an energy state. Under normal conditions, there are far more energy states than particles, so this is not a problem. However, a WD is compressed to the point that all energy states available to the electrons are occupied. Thus, any more compression would result in degeneracy. Since quantum mechanics forbids this, the electrons provide an outward force that we call degeneracy pressure. In a WD, electron degeneracy pressure far exceeds normal gas pressure, and thus electron degeneracy pressure is responsible for nearly all the pressure to maintain hydrostatic equilibrium. Even in so-called normal stars, such as the sun, some electron degeneracy pressure exists in their cores.

We ought to mention one other peculiarity about WDs. Hydrogen is by far the most abundant element in the universe, accounting for about 75% of composition by mass. This is typical composition of stars. However, if any hydrogen existed within a WD, the pressure and temperature present would result in rapid thermonuclear fusion of the hydrogen into helium. Thus, WDs must consist of other elements. Helium is probably one of the more important elements present, but other elements, such as carbon and iron, probably are present as well. The only place where hydrogen may exist in a WD is near the surface, in a kind of atmosphere where even electron degeneracy pressure may not be significant. We will discuss the importance of this possibility shortly. Absent the possibility of flare-ups caused by the fusion of hydrogen introduced to a WD, a WD does not produce energy. Instead, WDs shine by gradually tapping their enormous store of thermal energy. The calculated lifetimes of WDs—the period of time over which we can see them—exceeds many tens of billions of years. Since WDs do not normally undergo nuclear fusion, by definition they are not stars but instead are the first type of stellar remnant.

One result of the theory of WDs is the prediction that there is a maximum mass for WD stars. We call the upper limit to WD mass the Chandrasekhar limit, after the Indian-born American astrophysicist who was one of the first to deduce WD structure. The exact value of the Chandrasekhar limit depends upon the composition, but the largest mass possible for any composition is about 1.4 times the mass of the sun. Since WDs are so common in binary stars, we have much data to test this theoretical result. We find WD masses range from about 0.5 solar masses to 1.4 solar masses, with a cluster of stars near this upper limit. This is powerful evidence in support of WD theory. Theoreticians have been able to explain many other aspects of WD stars. We do not have room to expound upon them here. Suffice it to say that we probably understand the structure of WDs better than any other stars, including the sun.

As strange as WDs are, there are stranger objects still. In 1967, astronomers discovered the first neutron star (NS). Since then, astronomers have found about 1,500 additional NSs. NSs have masses greater than 1.4 solar masses. The upper limit for a NS is less certain than with a WD, but most models suggest an upper limit of around 3 solar masses. NSs are very small, only a few km across. This means that the density of a NS is many orders of magnitude greater than the density of a WD. The density of a NS is comparable to the density of the nucleus of the atom. Because NSs are so small, they are not very bright and we cannot see them with ordinary means at typical stellar distances. There are two ways to detect a neutron star; we will describe one of those methods now, and we will discuss the other later.

In 1967, astronomers discovered point radio sources that rapidly flashed, or pulsed, on and off. Since these objects pulsed, astronomers called them pulsars. Pulsars have very regular periods between their pulses, so regular that they keep very good time. The identity of pulsars remained a mystery for a short while. Astronomers soon realized that a rapidly rotating NS could explain pulsars. NSs had been predicted three decades earlier, but normally they would be so faint that we could not see them. Pulsars appear to pulse because they rotate very quickly and have very intense magnetic fields. If a pulsar originally were a much larger star, then as that star shrank/collapsed to form the NS, conservation of angular momentum demands that the rotation period decrease dramatically. Additionally, a sort of conservation of magnetic flux requires that the magnetic field greatly increase as well. As the NS rapidly rotates, it carries its strong magnetic field along with it. The rapidly moving magnetic field would greatly accelerate any charged particles near the surface of the NS. Highly accelerated, charged particles radiate in a particular way. Given this setup, we would expect that the radiation would be concentrated along the magnetic field poles. As the NS rotates, the magnetic field, and hence this beamed radiation, would sweep out in a cone, much like a searchlight does. If we lie along the cone swept out by the beam, then we will see a pulse each time the star rotates.

Is there any evidence for this scenario? Yes. Theory tells us that the beam must be polarized in a particular way and that it has a power-law spectrum. We call this kind of radiation "synchrotron radiation," because scientists first observed it coming from a type of particle accelerator that we call a cyclotron. Synchrotron radiation is very distinctive and occurs only when there is a powerful magnetic field rapidly moving with respect to charged particles. The radiation from pulsars matches those predictions very well.

Once astronomers realized that NSs existed, they began to speculate that black holes may exist as well. A black hole (BH) is a region of space that contains so much matter packed into such a small volume that the surface gravity prevents everything, including light, from escaping. Presumably, a BH must have mass greater than the roughly 3 solar mass upper limit for a NS. Notice that there is no upper limit on BH mass. A BH that is near the lower limit of mass is slightly smaller than a NS. However, as BH mass increases, the size of the BH increases. For some time astronomers have recognized the existence of two types of BHs: those with stellar masses and massive BHs. There is now good evidence that massive BHs lurk at the centers of many galaxies, including our own Milky Way. The mass range of stellar BHs may extend to a few tens of solar masses. Massive BHs may contain a million times the mass of the sun or more. Recently, astronomers have begun to consider the possibility of the existence of intermediate mass BHs.

What evidence is there for the existence of stellar BHs? Binary stars are very common. Suppose that a BH exists in a close binary star. If the stars in the binary system are close together, then the gravity of one star may pull matter off the other star and onto itself. The BH would produce tremendous tides on its companion, leading to mass transfer from its companion. Because the matter in falling onto the BH possesses angular momentum, the mass does not fall directly onto the BH. Instead, the matter orbits in a disk close above the event horizon of the BH. Astronomers call this disk an accretion disk (AD). From the AD, matter slowly spirals onto the BH. As matter from the companion star falls onto the AD, it converts a huge amount of gravitational potential energy into kinetic energy. Collisions and viscous motions of matter falling onto the AD thermalizes the AD, leading to very high temperatures in the AD. The high temperature leads to copious x-ray emission from the binary system. It is difficult to produce so much x-ray emission, so these objects readily stand out in surveys done with x-ray telescopes. Astronomers call an x-ray emitting binary system an x-ray binary (XRB).

We know that an XRB requires the presence of a compact object, a very small, massive object. Only a compact object has a steep enough gravitational potential well to account for the x-rays. The only compact objects that we know of are NSs and BHs. That is, the existence of an XRB implies the existence of either of these compact objects, but the existence of an XRB alone does not tell us which one. Can we determine which one? Fortunately, there is a way. Binary stars provide us with the only direct way of determining stellar masses. Recall that there is an upper limit to the mass that a NS may have. If we solve the observations to determine the mass and find that the mass of the compact object is below the upper limit of a NS mass, the compact object probably is a NS. However, if the compact object's mass exceeds the upper limit of the mass of a NS, the compact object is almost certainly a BH. Astronomers have identified a number of BH candidates, compact objects in XRBs whose masses exceed the NS upper limit. Additionally, astronomers have found a number of NSs in XRBs. This is the second method of NS detection.

Ancient astronomers coined the word "nova" (meaning "new") to refer to a new star that occasionally appeared. Even the ancients noted that novae generally disappeared after a few days. We now understand that a nova is an eruption in a star that causes the star to brighten tremendously before fading back to normal. In the case of ancient novae, the stars that erupted were too faint for anyone to see before or after the eruption. Modern astronomers have managed to identify stars before and after eruption in many cases. Since the 1920s astronomers have known about the existence of supernovae. A supernova is about 10,000 times brighter than a nova.

Modern theories about novae and supernovae developed in the 1960s and 1970s along with the development of stellar evolution. Astronomers think that novae occur in close binary stars, where one of the two stars involved is a WD. In a close binary system, the two stars are tidally distorted so that instead of spheres, the stars may be estimated as prolate spheroids with their longer axes pointing toward one another. Astronomers have developed the Roche model to describe such stars. We can calculate the surface of the Roche lobes, the boundary around the two stars where material is at an equal gravitational potential. Matter on a Roche lobe is sort of shared by both stars, so material there can easily move from one star's lobe to the other star's lobe. If the stars are close enough to one another, one star may fill its Roche lobe so that matter may transfer from that star to the other. Is there direct evidence of this? Yes, particularly in eclipsing binaries. We often detect the hot spot where matter falls onto the recipient star's surface. In many eclipsing binary systems, the transferring matter does not fall directly onto the recipient star, but first falls into a hot gaseous AD orbiting the recipient star. In some close eclipsing binary star systems, we see the spectrum of the AD. Astronomers have been very successful in using the spectroscopic data to model ADs.

Suppose a WD is the recipient star. Most of the matter falling onto the AD and then ultimately upon the WD would be hydrogen. Soon a layer of hydrogen builds up on the WD's surface. The temperature and pressure in the base of this layer slowly increase until thermonuclear fusion begins. With the release of energy from the fusion, the temperature in the hydrogen layer rapidly rises, which triggers runaway thermonuclear fusion. Soon, all the hydrogen is consumed. Normally, thermonuclear fusion occurs in a star's core, but in this situation the fusion occurs on the star's surface. With no overlying layers to muffle and modify the eruption, the star rapidly brightens and then gradually fades. We see this eruption as a nova. Since the nova eruption does no serious harm to the stars involved, the mass transfer sets in again, setting the stage for future repeat eruptions.

This type of nova is a classical nova. For many years, astronomers have recognized that there is a continuum of many kinds of nova from the classical novae down to much fainter types. If the physical conditions allow the hydrogen fuel to build up on the WD over a long time, then much fuel will accumulate and the subsequent eruption will be very large. This is a classical nova. After an eruption, classical nova will repeat with thousands of years between each eruption. Since this is a very long time, we do not recognize that these events repeat. On the other hand, if the physical conditions do not permit the huge buildup of hydrogen on the WD, but instead the fuel is consumed over a short period, the eruptions will be far more frequent but not as large. Alternately, the hydrogen may not readily fuse. Instead, brief, low intensity flaring may result from the liberation of gravitational potential as matter falls upon the WD in a clump. These recurrent novae may take only a few minutes to repeat, and they result in a much smaller brightening of the host star. There is much evidence to support this theory of the binary nature of novae of all types.

Supernovae (SN) are very different from novae. By the 1930s, astronomers realized that there must be two types of SNs, type I and type II. This distinction was based upon the different spectra that we see—type II has strong hydrogen emission lines, while type I has weak or absent hydrogen lines. There are differences in the rate at which the two types of SN brighten and fade as well. By the 1960s astronomers began to develop theories that explained the two types. Astronomers think that a type I SN occurs when a WD in a close binary system gains enough mass to transgress the Chandrasekhar limit. When this happens, the WD implodes, releasing a huge amount of energy (the SN explosion). A number of exotic physical processes come into play during the SN. Most theorists think that the SN eruption completely disrupts the star so that no remnant remains. Incidentally, since all progenitors of type I SN are a consistent set of objects, the eruptions are very similar in characteristics, such as peak luminosity. Of particular interest is a subclass of SN, the type Ia. Since we think we know how bright a type Ia SN is, we can compare the observed brightness to find distance to a particular type Ia SN. Because type Ia SNs are extremely bright, they provide a very powerful method for finding distances.

A type II SN is very different from a type I. Type II SN progenitors appear to be very massive stars. Stellar models suggest that massive stars undergo nucleosynthesis in their cores up to and including iron. Nucleosynthesis beyond iron to release energy is not possible, so at this point a massive star has no further energy options, except for gravitational contraction. As the core contracts, the core is supported by electron degeneracy pressure, but that fails when the mass of the portion of the core that is supported by electron degeneracy pressure exceeds the Chandrasekhar limit. When that happens, the core catastrophically collapses to produce either a NS or a BH. The rapid contraction of the core releases an incredible amount of energy that works its way outward through the outer layers of the star. This takes a few hours, upon which the outer layers greatly heat and expand to produce the SN explosion. Over the ensuing months and years, the expanding gas cools, causing the SN to gradually fade. The exponentially fading light curve has been attributed mostly to the decay of radioisotopes produced in the explosion.

In 1987, we got an unprecedented opportunity to view a SN up close. Early that year, SN 1987a erupted in the Large Magellanic Cloud (LMC), a nearby small satellite galaxy of the Milky Way. This was the first naked-eye SN since the invention of the telescope four centuries ago. In good confirmation of theory, a neutrino detector on the earth measured a flurry of neutrinos for a few seconds about a day before the SN became visible. The neutrinos would have originated with the core collapse and traveled unencumbered through the outer layers of the star, which explains their arrival a few hours prior to the optical detection of the SN. However, SN 1987a was an odd event. For the first time astronomers were able to identify the progenitor star, but the progenitor was a blue super giant star, rather than the expected red super giant. Furthermore, SN 1987a was not as bright as most type II SNs. There were other peculiarities as well.

What becomes of the expanding outer layers from a type II SN? We have been able to identify several expanding gas clouds with some historical SNs. One obvious example is the expanding debris about SN 1987a, which astronomers continue to monitor. Another example is the famous Crab Nebula that coincides with the location of a SN first glimpsed on July 4, AD 1054. Astronomers have observed the expansion rate of the debris to estimate the size, distance, and age of the Crab Nebula. This age agrees very well with the historical date of the SN. As a bonus, the Crab Nebula contains one of the first pulsars discovered. This makes the Crab Nebula and its pulsar an exceptional lab for exploring SNs and their development (DeYoung, 2006). Astronomers have discovered many other similar expanding clouds that appear to be the debris from SN explosions. Astronomers call these clouds SN remnants. Readers may be aware that Davies (1994, 2007) has cited SN remnants as an evidence for recent creation.

Many people confuse a SN remnant with a planetary nebula (PN). Despite their name, PNs do not have anything to do with planets. Through a small telescope, brighter PNs have a small, disk-like appearance, similar to a planet, so astronomers a couple of centuries ago named them thus. A good example of a PN is the Ring Nebula. A typical PN is a roughly spherical shell of gas; however, astronomers have come to realize that PNs often have a much more complex structure. A PN is smaller, fainter, and far less bright than a SN remnant. Interestingly, PNs always have very hot WD-like stars at their centers. This suggests that there is an intimate relationship between the two.

Evolutionary Framework

Actually, we already have discussed some of the evolutionary framework. In this section, we will briefly present the evolutionary ideas that connect some of the various remnants already described. Modern theories of stellar structure and evolution began to emerge in the 1950s through a series of important papers. One of the most important was the landmark work of Burbidge, Burbidge, Fowler, and Hoyle (1957), usually referred to as BBFH. BBFH identified many of the important thermonuclear reactions that we think power stars. Using well-understood physics, we can model the physical conditions within the cores of stars. These calculations reveal that the temperature and pressure present in stellar cores permit thermonuclear reactions.

Thermonuclear fusion of lighter elements into heavier ones generally is exothermic up to and including iron. The first step, the fusion of hydrogen into helium, releases about $^7/_8$ of all the energy that fusion reactions can produce. Hydrogen is by far the most abundant element in the universe, so this reaction accounts for most of the energy that stars can produce. Astronomers think that this reaction powers stars on the MS. Hydrogen fusion results in very long lifetimes of stars. Lower-mass stars have longer MS lifetimes, while the higher-mass stars have shorter lifetimes. Calculation shows that the sun can last about 10 billion years while using this reaction. Incidentally, this is the major motivation of creationists who reject thermonuclear reactions in the sun in favor of the Kelvin-Helmholtz mechanism. If the sun were powered by gravitational contraction, then the sun and the earth could not be billions of years old. But, alas, the case for thermonuclear reactions in the sun is very good (See DeYoung and Rush, 1989, and Newton, 2002).

When a star exhausts its hydrogen fuel in its core, the star must find an alternate energy source. Since core hydrogen fusion is a characteristic of MS stars, stars that have exhausted their core hydrogen must leave the MS. Let us explore the theoretical development of post-MS stars that astronomers have developed. The first energy source available is gravitational contraction of the core. When a star's core contracts, the core gets hotter and denser and the pressure increases. Paradoxically, as the core shrinks and heats, the star's outer layers expand and cool, producing a red giant. This is because as the core heats, its energy radiates into the surrounding layers. The surrounding layers are a gas, so as that gas heats, it expands and cools. What happens next to a star depends upon its mass. Astronomers expect that an extremely low-mass star will not ignite any further reactions. However, since the MS lifetime of a low-mass star exceeds the big bang age of the universe, astronomers do not expect that this eventuality has yet happened.

With greater mass, the temperature and pressure around the core may be sufficient to initiate fusion of hydrogen into helium in a thin shell around the core. Astronomers think that most red giant stars get their energy from this mechanism, so they sometimes call red giant stars shell-source stars. The shell fusion gradually eats away the hydrogen from the lower part of the envelope (everything outside the star's core) and adds the product of the fusion, helium, to the core. The accumulation of mass to the core causes the core to slowly shrink, with corresponding increases in temperature, density, and pressure. Incidentally, through its evolution the core of a star increasingly relies upon electron degeneracy pressure to provide pressure to balance the inward force of gravity.

If a star has enough mass, the temperature and density may reach the point that allows the fusion of helium into carbon. This process is called the triple-α process, because it involves three helium nuclei, and helium nuclei are sometimes called α particles. As with most thermonuclear processes, the triple-α process critically depends upon temperature. Once the triple-α process begins in the core, it releases energy that rapidly heats the core, which rapidly increases the rate of the helium fusion. Astronomers call this the helium flash. The helium flash causes the core to re-expand and cool a bit, with a corresponding shrinking and warming of the stellar envelope. In other words, the star appears to heat and shrink gradually. On the HR diagram the star would move from the upper right down toward the MS. Astronomers think that the star eventually settles onto the horizontal branch, so called because stars there lie on a horizontal region above the MS. The horizontal branch shows up prominently on the observational HR diagrams of globular star clusters. The horizontal branch ought to be the longest-lived branch that a post-MS star experiences. This is because the fusion of helium into carbon produces most of the remaining energy available in fusion reactions (hydrogen fusion, as we already stated, produces the bulk of energy available from fusion).

Eventually the helium in the core will be exhausted, leaving only carbon. Generally there will be no more fusion source available to the star, so the core will gradually shrink and heat once again. As before, this process leads to an envelope that is extended and cooler—the star once again progresses into the red giant region of the HR diagram along a path that parallels the earlier jaunt up to become a red giant. Astronomers call this second ascent the asymptotic giant branch (AGB). The lower envelope of AGB stars is in contact with the hot, dense core. Astronomers think that a thin outer region around the core fuses hydrogen into helium, as happened along the red giant branch. Also as before, this fusion builds up helium around the core. However, an AGB star ought to permit fusion of this helium into carbon immediately around the core. Thus, astronomers say that AGB stars are double-shell source stars.

Recall that the triple-α process commences rapidly. We expect that the helium fusion in the inner shell would start abruptly, consume most of the helium, and expand the shell slightly, all of which causes a decrease in the triple-α process. Thus, the fusion in the shell will be episodic, and this episodic behavior will spill over into the outer shell, affecting the fusion there, and into the envelope. During these episodes of fusion, theoreticians expect that additional elements may be fused. Helium nuclei can fuse with carbon nuclei to form oxygen nuclei. The oxygen nuclei can in turn fuse with helium nuclei to form neon, and so forth. This process is called successive α capture, because it involves the successive fusion of helium nuclei onto gradually more massive nuclei. Since helium has an atomic number 2 and oxygen 8, successive α capture produces even numbered elements up to iron (atomic number 26). The process ends with iron, because fusion of heavier elements beyond iron is endothermic.

During some of the episodes of thermonuclear fusion, astrophysicists think that some elements heavier than iron are produced. Some of the energy released by fusion goes into producing transferric elements. The most efficient way to do this is through neutron capture. Some reactions release neutrons, which in turn can fuse with other nuclei. As a nucleus gains neutrons, its atomic mass increases, but its atomic number does not. With increasing atomic mass, the nucleus becomes unstable. An unstable nucleus can decay by ejecting an α particle, but more often it emits a β particle. A β particle is an electron or its antiparticle, the positron. Effectively, β decay happens when in the nucleus a neutron transmutes into a proton, shedding the electron in the process. A β decay does not change the atomic mass of a nucleus, but it does increase the atomic number, changing the nucleus into the next element on the periodic table. If a nucleus is bathed in a large number of neutrons, the nucleus may acquire a large number of neutrons before it decays. We say that the nucleus has undergone rapid (r) neutron capture, because the nucleus captured the neutrons too rapidly to decay between captures. On the other hand, if the nucleus acquires neutrons slowly enough to decay between captures, then we say that it has undergone the slow (s) neutron capture process. The products of the r- and s-processes are very distinct, because the two processes produce different atomic nuclei (elements). In the episodes of thermonuclear fusion in AGB stars, some neutrons are produced, but not enough to lead to the r-process. Therefore, AGB stars produce s-process elements.

Episodic nucleosynthesis also causes thermal instabilities throughout the envelopes of AGB stars. This allows for convection throughout the envelopes of AGB stars. This is unusual, because most stars are not fully convective in their envelopes, but especially not in the regions around their cores. The lack of deep convection in most stars confines the products of thermonuclear fusion to their cores. However, the deep convection in AGB stars dredges up the products of nucleosynthesis up to their photospheres where we can observe them in the spectra of the stars. This can lead to unusual composition in AGB stars. For instance, carbon stars have an overabundance of carbon compared to normal stars, which produces unusual spectra. The related metal stars have high amounts of s-process elements. Metal stars frequently have technetium, an element that has no stable isotopes. Since the half-lives of all isotopes of technetium are far less than the supposed ages of metal stars, astronomers reason that the technetium must have been recently produced and dredged to the surfaces in these stars.

How does a star end its existence? The answer depends upon the mass of the star. As stars process their nuclear fuel, the mass of the core gradually grows, while the core size slowly shrinks. The role that electron degeneracy pressure plays in the structure of the core gradually increases. Astronomers think that a very massive star will pass through all the stages described here and perhaps through much successive α capture. Eventually, the mass of the core exceeds the Chandrasekhar limit, resulting in a type II SN. The collapsed core remains as either a NS or a BH, depending upon how much mass remains in the core.

A less massive star will have a very different end. The core will never have enough mass to implode to produce a SN. As the star expands into a large red giant during its later stages, the matter in its photosphere will be poorly bound to the star. Gravity in the photosphere is so weak that any small push will lift the matter in the photosphere from the star. This produces a stellar wind. Astronomers have realized for some time that red giant stars are very windy. Wind loss rates can exceed 0.0001 solar masses per year. Obviously a star with this loss rate could not exist for more than a few thousand years. Once a strong stellar wind sets in, the wind rapidly accelerates. Eventually, most of the envelope escapes, revealing the core. The core is very hot and is mostly supported by electron degeneracy pressure. This is how astronomers think that WDs form.

What becomes of the gas driven off by the stellar winds? The first material to leave is moving the slowest, while the later material is moving progressively faster. The faster moving material overtakes and plows along the slower moving material, compressing and heating the gas. Ionizing radiation from the exposed core also heats the gas. In a simple model, the expanding gas assumes a spherical shell shape around the exposed core. In a more complicated model, the gas can assume other shapes, such as an hourglass. This expanding gas is what astronomers think that a PN is. PN's always appear to have a hot, WD-type star at their centers. This is good evidence of this scenario. On the other hand, most WD stars do not have a PN around them. How can this be? A WD will exist for a very long time, but a PN has a very short lifetime. Thus, if a WD is more than say, 100,000 years old, then the PN that once surrounded it has dissipated into the interstellar medium.

Conclusion

Astronomers have developed an elaborate evolutionary explanation for a host of astronomical bodies interpreted as stellar remnants—giant stars of various types, supernovae, planetary nebula, neutron stars, and black holes. How have/can creationists respond to all this? One extreme approach would be to note the vast time required to accomplish these processes and simply deny that any of these have happened. This attitude would obligate us to provide alternate explanations for these various objects. For instance, if a planetary nebula is not gas ejected from its central star, then what is it? The other extreme would be to embrace much of these explanations, but on our terms. For instance, some creationists have proposed that there was a time of rapid change sometime in the past. The accelerated nuclear decay proposed by the RATE project offers the possibility of rapid stellar development early in the universe. The Humphreys white hole cosmology allows for vast periods of time to have elapsed elsewhere in the universe while only a few days passed on earth during the Creation Week. The Humphreys cosmology might allow for much of the stellar development briefly described here. A very small minority of recent creationists believe that the Creation Week refers to the creation of the earth and its biosphere rather than the entire universe. This view would allow the acceptance of virtually all of evolutionary stellar astronomy.

Another alternative is somewhere in the middle, carefully choosing what interpretations of evolutionary astronomers to accept and reevaluating others. Indeed, this seems most promising and is already pursued by some creationists. We will raise a series of questions in this vein. For instance, most creationists seem to accept that supernovae are the deaths of some stars. Did the stars that exploded pass through the various stages of development briefly described here leading up to their deaths, or did God create these stars already in "aged" states that caused them to die not long after their creation? Since we know when the Crab Nebula supernova happened and that there was a neutron star left behind, at least in that particular supernova, then did other neutron stars originate in supernova explosions? Astronomers can estimate the ages of neutron stars by their slow-down rates, and those ages typically exceed a few thousand years. Many creationists would simply respond that God created neutron stars with various "ages." Many neutron stars have no surrounding supernova remnant, suggesting that they formed long enough ago that their associated remnants have dissipated. The dissipation time is far greater than a few thousand years, so did God create these neutron stars directly? Did God create "fossil" stars? Creationary geologists would object adamantly if this were suggested in the realm of fossils of biological origin (i.e. fossils of plants and animals were planted in the ground by God). Is the astronomical realm so different?

Or consider planetary nebulae and white dwarfs. We already discussed the fact that planetary nebulae have hot white dwarf stars at their centers, suggesting the link between the ejection of planetary nebulae and the birth of white dwarfs. We can estimate the approximate age of a planetary nebula from the time required to eject the planetary nebula from the central star. The typical age is tens of thousands of years, longer than the age of creation by about an order of magnitude. Did God create planetary nebulae already expanding as if they had originated from a central star, when in reality the gas in the planetary nebulae never actually left the star? Lacking an internal energy source, white dwarfs must tap their considerable store of internal heat and so they must cool as they age. From their temperature, we can estimate the ages of white dwarfs. These ages typically are far greater than a few thousands of years. Did God create white dwarfs with various ages? Many creationists would answer yes to both of these questions.

Or consider the various types of red giant stars. If astronomers' physical explanations for these stars are reasonably correct, then to get into such aged states the stars would have required considerable time. Since the creation model does not allow for such great time, did God make these stars already in their aged states? What of type II supernovae? If type II supernovae really are the death processes of very massive stars, then did God create them on the threshold of death? Again, many creationists would answer yes to both questions.

While these affirmative answers are certainly possible and are the choice of many creationists, these answers do cause philosophical and theological problems for other creationists. Many creationists view the aging and death processes of stars, as well as stellar remnants, such as black holes, as part of the curse. Indeed, many of these processes are dictated by the second law of thermodynamics, which many creationists think originated at the Fall. If so, then when did these aging and dying processes occur? If after the Fall, then how did the light get here? If before the Fall, then is that consistent with a creation that was declared "very good?" The answers to these questions rely upon one's answer to the light travel time problem, a topic that we will not explore here. The answer also depends upon how one views the physical extent of the Fall. For instance, if the Fall did not invoke the second law of thermodynamics and/or if the Fall had limited extent outside the earth, then these questions are not nearly as problematic.

We have posed many questions here, but offered few definitive answers. The field of creation stellar astronomy is still in its infancy. The author has few answers for many of these questions at this time, and he hopes that this brief discussion can lead to further discussion and research.

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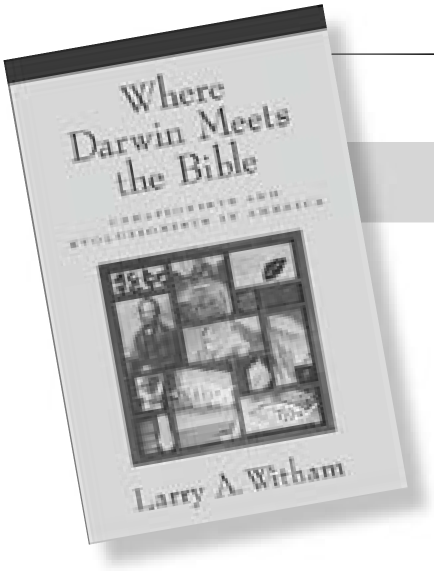
Where Darwin Meets the Bible
Creationists and Evolutionists in America
Larry A. Witham

Book Review

Where Darwin Meets the Bible: Creationists and Evolutionists in America

by Larry A. Witham

Oxford University Press, New York, 2002, 330 pages, $30.00.

Since the publication of Charles Darwin's *On the Origin of Species* in 1859, the conflict between evolution and creation has been an enduring, often heated, schism in American life. This long-standing debate has seen a number of high-profile cases—for example, the Scopes trial (1925), the *Edwards v. Aguillard* Supreme Court decision (1987), and the Kansas science standards debate (1999).

Over the years the contours of the debate have shifted, at times dramatically. *Washington Times* reporter Larry Witham has been a student of this ongoing controversy for some time. In researching *Where Darwin Meets the Bible*, Witham conducted over 200 interviews with prominent players in this saga - scientists, philosophers, theologians, and writers. Witham succeeds remarkably well in putting together a balanced, accurate, well-documented, and nonjudgmental account that is both highly readable and most engaging.

Witham visits numerous venues where the dialog has taken place, including high schools, universities, churches, courts, museums, and government offices. He presents the testimonies, largely unfiltered, of evolutionists, creationists, and observers. What emerges is a complex panorama of viewpoints that suggests that a continuing debate is unavoidable, with no clear resolution in sight.

Witham divides the players into four categories, not all-inclusive but generally valid. First, the pure evolutionists are those who accept only a material view of life and its development. These evolutionists rely on four principles: (1) there is no "supernatural intervention in nature," (2) there is no "interruption in the regularity of natural law" (i.e., miracles do not happen), (3) there is no "ultimate teleology" (design or purpose in nature), and (4) there are no "preordained 'types' in biological life" (i.e., evolution proceeds with no specific goals in mind) (p. 44). It goes without saying that pure evolutionists either reject God or see no role for Him in the origin and development of life.

Second, theistic evolutionists try to reconcile belief in God with Darwinian evolution. Divine action in this case is posited to occur only though natural processes. That is, God's intervention is so subtle it could never be detected by the methods of science. Certain theistic evolutionists might see God as a "first cause" who got the universe started. Following that, God lets evolution run its course. In this view, if the evolutionary process were to begin again, life would be entirely different than we experience today.

Third, progressive creationists, as defined by Witham, (1) acccept "some historic authenticity to the sequential Genesis days," and (2) allow "that divine intervention may override 'natural causation' in a singular act of creation" (p. 50). In other words, these are people who basically concur with the sequence of the Genesis 1 account, but who believe the Genesis "days" are really "ages" or "eras" lasting for thousands or even millions of years. Progressive creationists posit that God has intervened with creative acts at critical times in earth's history. Witham would include many in the intelligent design camp in this category, although design theory does not purport to identify the "designer," and some ID proponents do not consider themselves to be "creationists."

Fourth, young-earth creationists are those for whom "Genesis is taken at face value: a sudden Creation over days... from six to ten thousand years ago" (p. 52). Key tenets are "a young earth and recent man, the deterioration of a pre-Fall earthly paradise, and the geology of a [Noachian] flood" (p. 52).

In terms of the recent history of the controversy in America, Witham says the young-earth camp enjoyed a "fifteen-year heyday" from about 1972 to 1987 (p. 37). Hydraulic engineer Henry Morris and his Institute for Creation Research were key players duing this time. A key strategy of this movement was to promote the teaching of both evolution and "creation science" as theories for the origin and development of life, the so-called "equal treatment" proposal.

The U. S. Supreme Court, in the pivotal *Edwards v. Aguillard* case (1987), effectively ended this strategy by declaring that "creation science" is disallowed in public schools due to its religious underpinning. However, the 1987 Court did not completely close the door on alternatives to evolution. The ruling did allow for the possibility of "scientific critiques of prevailing scientific theories [to] be taught," and for "teaching a variety of scientific theories about the origins of humankind" (p. 149). While the high Court has not issued a more recent ruling in this area, many think that intelligent design would fit the description envisioned by the 1987 ruling.

The modern intelligent design (ID) movement, according to Witham, "emerged and matured in a window between 1984 and 1992" (p. 219). The movement began in 1984 with publication of the *Mystery of Life's Origin* by Charles Thaxton, Walter Bradley, and Roger Olsen. The next key book was Phillip Johnson's *Darwin on Trial* (1991). The ID movement has made inroads in the public policy area where creation science failed, largely because ID emphasizes the scientific evidence rather than religious claims.

Witham says the debate "has switched from defending religious scripture to making scientists explain the holes in evolutionary theory" (p.8). Materialism is still firmly entrenched in biological science, however. Witham states that "materialism is not in a crisis in biology, but the power of Darwinian evolution—mutations and natural selection—to explain all things seems to be" (p. 265).

What about the future? Witham says that "a type of creationism that ducks the age question, or that works with an ancient earth, and does not rely on apocalyptic backdrops is likely to take prominence in the next few decades. The obvious candidate is the intelligent design movement" (p. 264). Witham suggests that ID will dominate the scene over the next several years, and perhaps ID will eventually reach the status of a viable theory in science. But evolutionary theory has been able to stave off attacks in the past due to its firm grasp in the science establishment, and the road to change will likely be slow and perilous.

Witham concludes that the controversy over evolution's grip on biology "will finally be a legal matter" (p. 268). That is, the courts will have the final say over what is taught in schools regarding biological origins. Many expect a case over the validity of intelligent design as a competing theory to be the next major legal event on the horizon.

Where Darwin Meets the Bible covers the Kansas science standards controversy of 1999, which was really a battle of young-earth creationism versus dogmatic evolution. Witham's conclusion: "The Kansas story finally showed that a [young-earth] creationist push, whatever its motivation, cannot succeed in modern America" (p. 144).

In summation, Larry Witham has given us an excellent overview of the contentious struggle between Darwinian evolution and its alternatives. *Where Darwin Meets the Bible* provides an invaluable roadmap that lucidly describes the major players and diverse points of view. Many partisan perspectives on this issue have appeared in press, but for an unbiased account of the conflict, Witham's book has no equal.

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Book Review

By Design: Science and the Search for God

by Larry A. Witham

Encounter Books, San Francisco, 2003, 248 pages, $25.00.

By Design is a continuation of Witham's 2002 book on the origins debate, *Where Darwin Meets the Bible*. While the first book features evolution and creation science, *By Design* highlights the modern intelligent design (ID) movement.

Witham organizes his chapters mostly by subject, rather than by chronology. He starts out with modern developments in evolutionary theory, including the "modern synthesis" (or neo-Darwinism) developed in the 1930s–40s. The modern synthesis gave Darwinian theory a *genetic* basis (of course, the science of genetics was unknown in Darwin's day). Neo-Darwinism is a *gradualistic* theory. That is, new species are alleged to result from the accumulation of small changes over long periods of time.

Witham contrasts neo-Darwinism with the observation that new species generally appear in the fossil record *abruptly* rather than gradually. The lack of fossils showing transitions between species led some evolutionists to propose alternatives to the modern synthesis. Two of these theories are *punctuated equilibrium* and *saltation*.

Next, Witham explores the development of the Anthropic Principle and cosmology, the origin and development of the universe. The Anthropic Principle, introduced in the early 1970s, suggests that the universe is "finely-tuned" to favor the development of intelligent life on earth. Indeed, numerous physical constants in nature have very narrow tolerances so that a small change would preclude the development of life. These numerous cosmic "coincidences" suggest to many scientists that the universe has been designed by an intelligent agent.

Witham discusses in some detail the history of the big bang theory for the origin of the universe. This theory implies that the universe had a beginning, a conclusion consistent with intelligent causation (and a biblical "beginning"), but inconsistent with the materialist view that the universe has always existed.

Witham attributes the genesis of the ID movement to debates over the origin of life. In the 1920s the Oparin-Haldane hypothesis emerged. This opened up the field of "abiogenesis," or the chemical evolution of life. Oparin and Haldane proposed general scenarios by which complex biomolecules could emerge via chemical reactions on the early earth, leading eventually to the formation of living cells. The famous Miller-Urey experiments in the 1950s indeed showed that simple organic molecules (*e.g.*, amino acids) could be formed in experiments thought to simulate conditions on the early earth.

The Mystery of Life's Origin, a seminal book published in 1984, questioned the efficacy of the Oparin-Haldane proposal. Witham says that *Mystery* "offered the opening shot of a design proposal of material life" (p. 117). This book drew wide attention and inspired additional work in the fledgling ID field. Another key book was *Evolution: A Theory in*

Crisis (1985) by biochemist Michael Denton. The ID concept was expanded further in *Of Pandas and People* (1989) by biologist Dean Kenyon et al.

Witham gives a fairly detailed sketch of Phillip Johnson, who became the ID "movement's titular leader" (p. 129). Johnson, a Berkeley law professor, became interested in the origins debate when he visited England in 1988 and read evolutionist Richard Dawkins's book *The Blind Watchmaker*. In England Johnson also met and interacted with ID proponent Stephen Meyer. Returning home, Johnson wrote *Darwin on Trial* (1991), a book that "rapidly became a lightning rod for the origins debate" (p. 126).

Witham also describes the key contributions made by Michael Behe (*Darwin's Black Box*, 1996). Behe argues that many biological features and processes (like blood clotting and vision) are "irreducibly complex." These systems, Behe says, could not have formed by the gradual evolutionary processes of genetic variation followed by natural selection. *Darwin's Black Box* "became a turning point for the new design movement" (p. 129).

Witham also describes the work of mathematician William Dembski. Witham says that "Dembski's main contribution has been to propose a method to investigate nature" (p. 143). Dembski's method is the "explanatory filter." First, one asks whether a phenomenon in nature can be explained by the two basic naturalistic processes—chance (contingency) and necessity (natural law). If not, then an inference of design (intelligent causality) can be made. Biological molecules (*e.g.*, DNA, RNA, proteins) contain much highly specific *information*. Dembski argues that chance and necessity cannot generate information; "only an intelligent agent can" (p. 146).

Witham spends some time describing the work of the Discovery Institute in Seattle, a think tank that has become the intellectual center of the ID movement. The Access Research Network, a key source of information on the origins debate, is also described. One surprising omission in Witham's book is the lack of any detailed coverage of John Calvert's Intelligent Design Network. This organization has become a key group working with citizens in various states on the legal and scientific issues associated with the evolution/design debate.

Witham devotes only a relatively small portion of his book to the public dialogue on evolution and design. He talks about an early debate between Phillip Johnson and evolutionist Stephen Jay Gould. He describes the pro-Darwin *Evolution* series on public television (2001) and the Discovery Institute's efforts to show the shortcomings of the series. Witham spends several pages detailing the 2002 science standards debate in Ohio. This resulted in the first state standards for schools that use a "neutral" (non-naturalistic) definition of science and also call for investigation and critical analysis of evolutionary theory.

At the end of the book, Witham devotes a chapter to Darwin's "Tree of Life," the theory that all life has a common ancestry. Witham discusses key problems with this theory, including the lack of continuity in the fossil record and the Cambrian explosion. In Cambrian fossils, numerous "disparate body plans seem to have burst out of nothing" (p. 179). The Cambrian "does appear to be a genuine explosion demanding an explanation" (p. 180).

Witham also includes a chapter on the mind and brain, another serious challenge for Darwinian theory. In this Witham considers the matter of the "classic dualism of eternal mind and perishable body" (p. 191). The key question discussed is whether mind (consciousness) could emerge from a material (physical) source. Many scientists conclude that an intelligent cause is needed to explain the mind, "a nonmaterial force" (p. 204).

Witham has studied evolution, creation science, and intelligent design movements over a period of years, and in his writing he correctly discerns the key aspects of the origins debate. At the heart is a struggle over the very definition of science. Modern science limits itself to the search for *natural* (material) explanations for phenomena, but "design advocates want science to look for the best explanation from the evidence" (p. 168). If the evidence suggests a nonmaterial cause, then this explanation should be given due consideration.

Witham also says that "intelligent design theorists tend to stay away from purpose [in nature] and focus on evidence for intelligence" (p. 141). The focus is on certain big questions, such as "consciousness, the origin of life, the remarkable effectiveness of mathematics at modeling the physical world, and the fine-tuning of universal constants" (p. 142). Current material explanations for these phenomena leave much to be desired.

Larry Witham is a journalist, and as such he tries to present a neutral viewpoint on the evolution/design debate. At times, he finds it difficult, however, to contain his enthusiasm for the objectives and methods of ID theory. In recent years, important discoveries in science (especially in biochemistry and cosmology) have shaken the Darwinian establishment to its foundations. More and more scientists are asking penetrating questions about the origin of the universe and the development of life on earth. The ID movement is becoming a key player in this debate, and science as we know it may well be approaching a new paradigm in which intelligent causality must be considered as the best explanation for many phenomena in the natural world.

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Deep Wells—Deep Time?

John R. Doughty*

Abstract

Radiocarbon is found throughout the geological record. The confirmation of this hypothesis in the cases investigated in this paper strengthens the young earth creationist paradigm. This research builds upon carbon isotope analyses done on diamonds, coal, carbon dioxide gas wells and coal bed methane (CBM) gas wells where significant amounts of radiocarbon were found, and extends it to the analysis of deep natural gas wells. The resulting radiocarbon data, given as percent of modern carbon (pMC), provide a strong indication that both the carbon dioxide (0.58 pMC) and methane (0.32 pMC) gases found in the Ordovician strata of two Valverde Basin natural gas fields are thousands, not hundreds of millions years old.

Introduction

This paper is the third in a series that show that significant detectable amounts of radiocarbon (^{14}C) can confidently be expected to be found in carbon dioxide and natural gas wells. The basis for such confidence stems from earlier experimental work by Baumgardner (2005) on diamonds and coal, and my recent experimental work on CO_2 and CBM gas wells (Doughty, 2005; 2006). This work experimentally verifies that carbon-14 is indeed present in the gases derived from very deep, Ordovician era, Ellenburger dolostone strata in two natural gas fields in the southwest Texas Valverde basin. Since carbon-14 has such a short half life of only 5,730 years, finding it in natural gas wells provides additional compelling evidence for the young earth position following a straightforward interpretation of the Holy Bible and in particular the Book of Genesis.

Background

A few years ago, Bernard Marty (2001) wrote an introductory article in *Nature* commenting on the work of Ballentine et al. (2001) regarding the age of CO_2 found in deep Valverde Basin natural gas wells. Marty noted that it appeared that gases such as CO_2 and CH_4 can be stored for much longer than has generally been assumed, specifically 280 to 300 million years. This is of particular interest to those concerned about global warming and the sequestration of carbon dioxide. Supposedly the CO_2 entered the Valverde Basin at the time of the Marathon Thrust uplift 300 million years ago. The hydrocarbon generation began 20 million years later and entered the fields at that time. If that is a correct conclusion, then there should not be any radiocarbon present in either the CO_2 or the CH_4. Also, if radiocarbon is found, the percent of modern carbon (pMC) value for CO_2 should be smaller (thereby older) than that for the CH_4 under the presumption that it preceded the methane. If the values are essentially the same, then one could conclude that they originated at about the same time and not too long ago.

Ballentine et al. (2001) conducted an extensive sampling (26 wells) of the Brown-Bassett and JM fields in southwest Texas. They noted that the gas temperature was uniform across the fields. Further, the values for the stable carbon-13 isotope for both CO_2 and CH_4 were within a narrow range varying primarily with the CO_2 concentration. Mean values for the 26 wells were $\delta^{13}C(CO_2) = -2.92‰$ pdb and $\delta^{13}C(CH_4) = -37.40‰$ pdb. The resulting fractionation factor, α, is 1.0358, which results in an equilibration temperature of 181°C (Faure

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and Mensing, 2005). However, Ballentine et al. (2001) wrote that "inorganic isotopic equilibrium between CO_2 and CH_4 does not occur on geologic timescales at temperatures less than 200°C." They referenced the experimental work by Sackett and Chung (1979), which indicated no reaction between essentially dry inorganic CO_2 and CH_4 and therefore no isotopic carbon exchange at temperatures up to 500°C. Therefore, Ballentine et al. (2001) logically concluded that the CO_2 and CH_4 found in the deep Valverde Basin wells had separate sources, the mantle for the CO_2 and the crust for the CH_4. While they did not mention the presence of water in the well gas in their paper, they did so in an earlier conference (Ballentine et al., 2000). Also, the *Atlas of Major Texas Gas Reservoirs* (Kosters et al., 1989) indicated that the Brown Bassett field had a water saturation of 35% and the JM field value was 20%. This is important because Seewald (2001, 2003) and Seewald et. al. (1998) have shown experimentally that the presence of water and catalytic minerals results in the rapid production of CO_2 from heavier hydrocarbons through decarboxylation (an organic reaction sequence). Long geologic time wasn't a factor in the kinetics, but rather there is a greater dependence on thermodynamic equilibrium constraints. Thus, the proper combination of pressure and temperature in the presence of water and minerals could rapidly produce the natural gas and organic alteration products (CO_2, etc.). If this was indeed the case for the Valverde Basin fields, then one would expect the carbon-14 values for CO_2 and CH_4 to be fairly close together, the primary hypothesis that motivated this work.

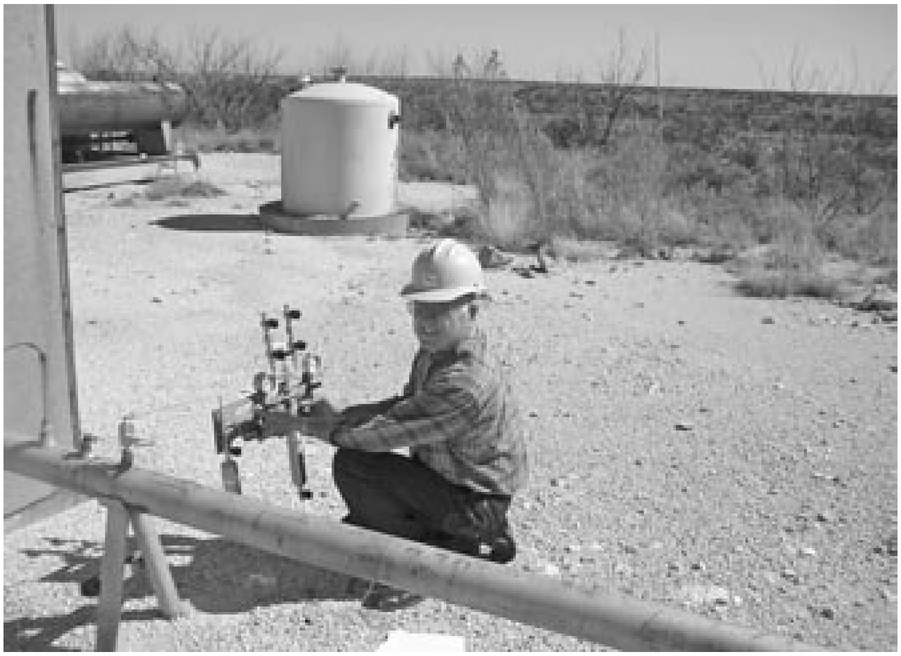


Figure 1: Sampling the Mitchell 5 #1 well.

Methods and Materials

The sampling apparatus and procedures used to sample and reduce the data are identical to that described previously (Doughty, 2006). The sampling apparatus can be seen in Figure 1, a photo taken at the Mitchell 5 #1 well site.

Results

As a result of a review of the work of Ballentine et al. (2001), three wells were selected to be sampled. The selection was based on sampling the wells with the highest, lowest, and an intermediate value for $\delta^{13}C(CO_2)$ and $\delta^{13}C(CH_4)$ as shown in Table I. Note that the production depth ranges from 2.5 to 2.8 miles

Table I. CO_2/CH_4 gas wells selected for sampling.

Well Sampled	Field	$\delta^{13}C(CO_2)$,‰ pdb	$\delta^{13}C(CH_4)$,‰ pdb	Production depth, ft.
Turk A No. 1	Brown-Bassett	-2.77	-37.68	13,718 to 14,697
Mitchell 5 No. 1	JM	-2.84	-37.57	13,736 to 14,490
Mitchell No. 3	JM	-3.06	-37.26	12,934 to 13,726

Notes:

1. Stable isotope data from Ballentine et al. (2001).
2. The mean value for $\delta^{13}C(CH_4)$ obtained earlier by Stahl and Carey (1975) was -38.14‰ pdb for gas wells penetrating the Ellenburger Formation across a major portion of the Permian Basin.

Table II. Well Gas Characteristics.

Field	Well sampled	Pressure psi	Temp. °F	CO_2, %	CH_4 %	N_2 %
Brown-Bassett	Turk A No.1	205	68	55.8	43.5	0.48
JM	Mitchell 5 No.1	200	96	53.1	46.3	0.36
JM	Mitchell No.3	202	100	21.5	77.7	0.54

Note: The data from the above fields are based on analyses performed in October and December 2005 by Manley Gas Testing, Inc. of Odessa, TX.

down. The well gas physical characteristics are shown in Table II. All wells had a water separator located upstream of the sampling port. Any residual traces of water were removed at the University of Arizona AMS lab. All samples were taken from producing (flowing) wells. Two identical samples were taken at each well site. The samples were analyzed for their isotopic content of $\delta^{13}C$, $\delta^{18}O$, and ^{14}C. The results are shown in Table III.

The stable isotope mean values are $\delta^{13}C(CO_2)$ = -2.69‰ pdb, $\delta^{13}C(CH_4)$ = -37.93‰ pdb, $\delta^{18}O(CO_2)$ = 25.74‰ smow where "pdb" and "smow" are the reference standards to which the data are compared. The "pdb" standard, PeeDee Formation Belemnite, for carbon-13 is defined as 0‰ and the "smow" reference for oxygen-18 is standard mean ocean water, where $\delta^{18}O$ = 0‰. The stable isotope ranges are shown in Figures 3 and 4 where they are compared with values for other sources.

The most important result is the radiocarbon data. The mean values for the carbon-14 results for the CO_2 are $^{14}C/C$(uncorrected) = 1.168 pMC and $^{14}C/C$(corrected) = 0.58 pMC and for the CH_4 $^{14}C/C$(uncorrected) = 0.578 pMC and $^{14}C/C$(corrected) = 0.32 pMC. Uncorrected values are given for future use and comparison since AMS labs do not have universally accepted procedures for the application of correction factors; i.e., the correction is lab specific. The corrected values for $^{14}C/C$ (CO_2) and $^{14}C/C$ (CH_4) are shown in histogram format in Figure 2.

Discussion

The JM and Brown-Bassett fields have a faulted anticline type of trap. The trap is supposed to be *tight*; i.e., no leakage into or out of the formation. The 300 million year date for the CO_2 emplacement was derived primarily by the best estimate of the geological community as to the timing of the Marathon uplift and secondarily from analysis of the CO_2 / ^3He ratio (Ballentine, Burgess, and Marty, 2002). The scenario is major faulting would allow juvenile magmatic CO_2 from the mantle to flow into the older Ordovician (440–500 million years) Ellenburger Formation. If that was truly the case, then the carbon-14 signature of the CO_2 flowing into the formation should have been in the range of 0.1 to 0.2 pMC, the same range as that for subsurface Precambrian diamonds (Baumgardner, 2005). Therefore, the carbon-14 CO_2 signature should have a lower value than the flood-deposited organics that produced the natural gas (primarily methane and ethane) found

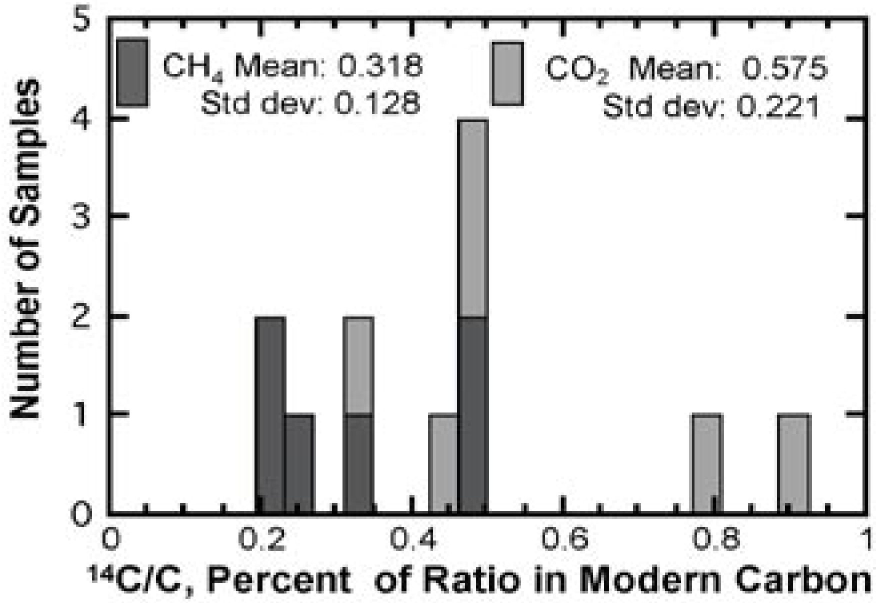


Figure 2. Distribution of 14C values for three Valverde Basin Natural Gas Wells.

Table III. Valverde Basin Ellenburger Formation Natural Gas Well Sample Isotope Values.

Well & Sample # *Suffix*: C=CO_2, M=CH_4	Mass mg	δ^{13}C, CO_2	δ^{13}C, CH_4	α, $CO_2 \leftrightarrow CH_4$	δ^{18}O, CO_2	^{14}C/C, pMC uncorrected	^{14}C/C, pMC corrected
Turk A No.1, #1C	0.791	-2.548			32.714	0.73±0.03	0.34±0.13
Turk A No.1, #1M	0.605		-38.451	1.0373		0.97±0.08	0.48±0.12
Turk A No.1, #2C	0.801	-2.528			32.535	0.83±0.05	0.45±0.13
Turk A No.1, #2M	0.578		-39.348	1.0383		0.59±0.03	0.31±0.10
Mitchell No.3, #3C	0.282	-2.893			22.770	1.84±0.06	0.77±0.35
Mitchell No.3, #3M	1.10		-37.472	1.0359		0.27±0.02	<0.20
Mitchell No.3, #4C	0.277	-2.791			22.760	1.66±0.28	0.92±0.30
Mitchell No.3, #4M	0.937		-37.368	1.0355		0.34±0.03	<0.20
Mitchell 5 No.1, #5C	0.627	-2.583			21.851	0.98±0.05	0.49±0.17
Mitchell 5 No.1, #5M	0.514		-37.303	1.0361		0.76±0.04	0.47±0.11
Mitchell 5 No.1, #6C	0.628	-2.584			21.793	0.97±0.04	0.48±0.16
Mitchell 5 No.1, #6M	0.514		-37.627	1.0364		0.54±0.04	0.25±0.11

Notes:

1. Stable isotope mean values: $\delta^{13}C(CO_2) = -2.69‰$ pdb, $\delta^{13}C(CH_4) = -37.93‰$ pdb, $\delta^{18}O = 25.74‰$ smow, fractionation factor: $\alpha(CO_2 \leftrightarrow CH_4) = 1.0366$.
2. $^{14}C/C$ corrected mean values: $^{14}C/C(CO_2) = 0.58$ pMC, $^{14}C/C(CH_4) = 0.32$ pMC.
3. All wells were sampled on 2/28/06.

in today's wells. The data from this work show that such is not the case, but rather the opposite.

The most noteworthy result is that the *fossil* methane has significantly detectable carbon-14. Further, the magnitude is basically the same for methane and CO_2 within statistical bounds in both the Turk A #1 and the Mitchell 5 No.1 wells. That would suggest a common origin, most likely at the time of the Flood. Also notable is that the oldest (49,920 years) and youngest (37,660 years) conventional age for the two gases occurred in the same well, the Mitchell No. 3 well, suggesting some possible infiltration of groundwater containing some dissolved atmospheric CO_2 subsequent to the deposition of the Ellenburger Formation.

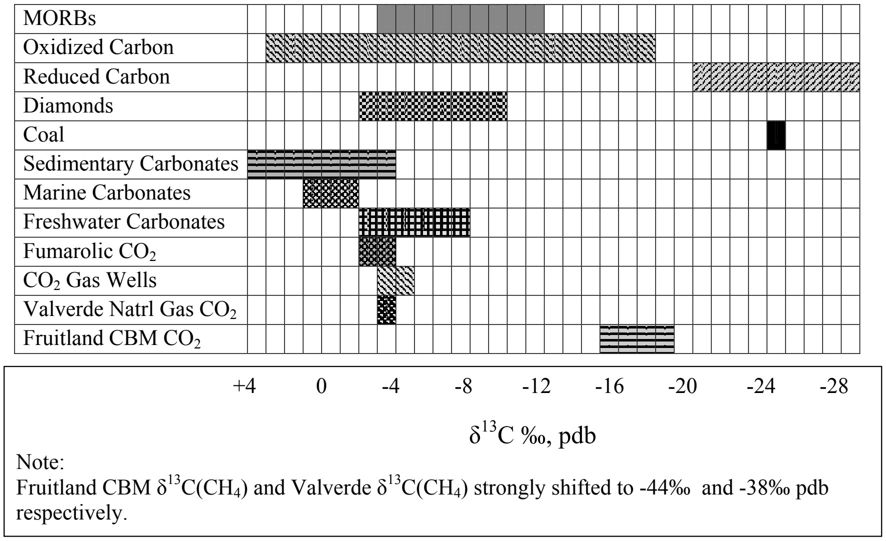
The data shown in Table III fit well within the previously reported range for carbon dioxide gas wells (^{14}C/C mean value of 0.361 pMC) and coal bed methane gas wells (^{14}C/C mean values from 0.53 to 1.48 pMC) as well as that from the overall Phanerozoic era (^{14}C/C range from 0.2 to 0.65 pMC) as shown in Baumgardner (2005).

The stable isotopes, $\delta^{13}C(CO_2)$ and $\delta^{18}O(CO_2)$ fall in the range of sedimentary rocks and carbonates as shown in Figures 3 and 4 respectively, but they do not point to a physical age of material. I was unable to find any data in the literature concerning δ^{18}O for any Permian Basin fields. However, the data from this work fits well with CO_2 gas wells and sedimentary rock values. The two Mitchell wells compare closely with CO_2 gas wells (δ^{18}O data mean value of 23.44‰ smow).

From the data for $\delta^{13}C(CO_2)$ and $\delta^{13}C(CH_4)$, the mean value for the fractionation factor, α, is 1.03660. That results in an equilibration temperature of 175°C or about 6°C cooler since Ballentine et al. (2001) took their samples, the effect of six years or so of pumping.

Conclusions

Once again, fossil gas is not carbon-14 dead. Thus, the age of the gases is on the order of thousands, not millions of years. The mean value for the methane-derived carbon-14 is 0.32 pMC, which is in reasonable accord with the mean value for Pennsylvanian coals (0.27 pMC) reported by Baumgardner



Note:
Fruitland CBM $\delta^{13}C(CH_4)$ and Valverde $\delta^{13}C(CH_4)$ strongly shifted to -44‰ and -38‰ pdb respectively.

Figure 3. Range of Carbon-13 values for various rocks and gases.

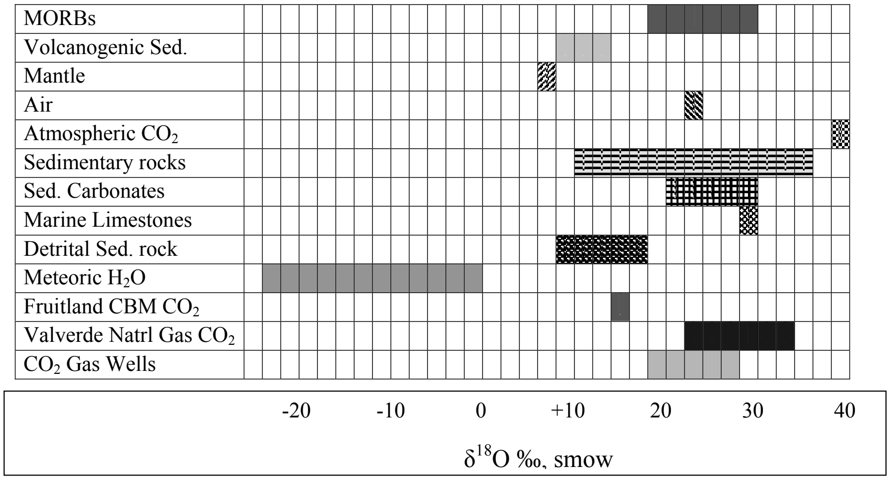


Figure 4. Range of Oxygen-18 values for various rocks and gases.

(2005). The $^{14}C/C$ mean value for CO_2, 0.58 pMC, is substantially less than that for coal bed methane (CBM) wells (Doughty, 2006), which have large amounts of water (mean value of 1.48 pMC). When compared to the relatively dry CO_2 gas well data (mean value 0.361 pMC) (Doughty, 2005), the deep well Valverde Basin gas shows only slight groundwater contamination influence. Carbon-14 can be a valuable diagnostic tool for isotopic analyses of other natural gas wells.

Acknowledgments

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Finally, I thank my wife, Jeanette, who accompanied me into the hinterlands. *"Far from where people dwell he cuts a shaft, in places forgotten by the foot of man"* (Job 28:4a).

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Book Review

Creation or Evolution—Does It Matter?

by Robert and Elizabeth Ridlon

Jordan Dill Associates, Bloomington, IN 2005, 195 pages, $12.00.

The Ridlons are part-time science faculty at Southwestern Illinois College. They frequently speak on creation science, and this book is a compilation of their seminar topics. The Ridlons present a very readable generalization of origins data, concentrating on biology and geology.

Little actually appears in the book concerning the title. This is unfortunate, since the many serious implications of evolution are rich areas to explore. The book instead ridicules evolution as the baseless story that we came from "slime" (p. 3). As an intricate, counterfeit theory of origins, evolution theory is not quite that simple.

The book has some embarrassing problems that can be corrected in future editions. The words *lightning* (p. 90) and *Becquerel* (p. 127) are misspelled. The authors state that new species do not arise, in conflict with observed speciation (p. 20). The authors describe a comet that struck Siberia in 1918 and doubled the carbon-14 content of the atmosphere. This event will be news to astronomers. Perhaps the authors are referring to the Tunguska Event of 1908, which may possibly have been a comet.

This book gives a clear presentation of the gospel. It would be a delight to hear the Ridlons speak while using this book as a guide.

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Investigation of Several Alleged Paleosols in the Northern Rocky Mountains

Part II: Additional Data and Analysis

Peter Klevberg*, Richard Bandy, Michael J. Oard

Abstract

Paleosols, "fossil soils," have been reported at several locations east of the Rocky Mountains in northern Montana, U.S.A., and southern Alberta, Canada. These alleged paleosols have been correlated between erosional remnants corresponding to the Flaxville Plain, an extensive surficial planar erosion surface. Based on correlation to magnetic reversals, a chronology of 2.6 million years has been published, supporting a uniformitarian paleogeographic and paleoclimatologic reconstruction that includes multiple glaciations. Fieldwork conducted at each of the alleged paleosol sites and laboratory analyses of selected samples of earth materials indicate that the paleosol interpretation is based on many questionable assumptions. Data are more readily interpreted from a diluvial perspective. Results of this investigation also indicate that pedostratigraphic and magnetostratigraphic "data" from other sites may need to be viewed with suspicion.

Introduction

The existence and origin of paleosols is a favorite argument of some anticreationists. But the argument is an example of a "mixed question" of both science and natural history (Klevberg et al, 2003), and its veracity is questionable. Several paleosols have been reported from the Kennedy Formation (Klevberg and Oard, 2005) and associated deposits in the northern Rocky Mountains of Montana and Alberta (Figure 1). Principles and methods of paleosol analysis (Klevberg and Bandy, 2003a, 2003b; Klevberg et al., 2003; Klevberg and Oard, 2005) render the uniformitarian interpretation even more suspect. Methods, goals, and field results of this project are described in our previous paper (Klevberg et al., 2007). Laboratory results and a discussion of the significance of both field and laboratory data are presented here.

Review of Previous (EGP) Data

Karlstrom (1988) presented a considerable number of laboratory data in support of a pedogenic origin for earth materials at the sites he investigated (see Figure 1), including X-ray analyses of clays (physils) indicating the presence of possible secondary minerals: kaolinite, chlorite, smectite, and vermiculite. While we agree that these data are probably accurate and representative of the materials sampled, results could reflect a complex history rather than a strictly pedogenic one. While secondary minerals and oxides (inferred from color) are typical of well-developed soils, they are not diagnostic of pedogenesis (Klevberg and Bandy, 2003a). Still unresolved is: (1) whether that soil formation occurred over long periods of time in superposed units and were only recently exposed in landslide scarps (Karlstrom's apparent position); or (2)

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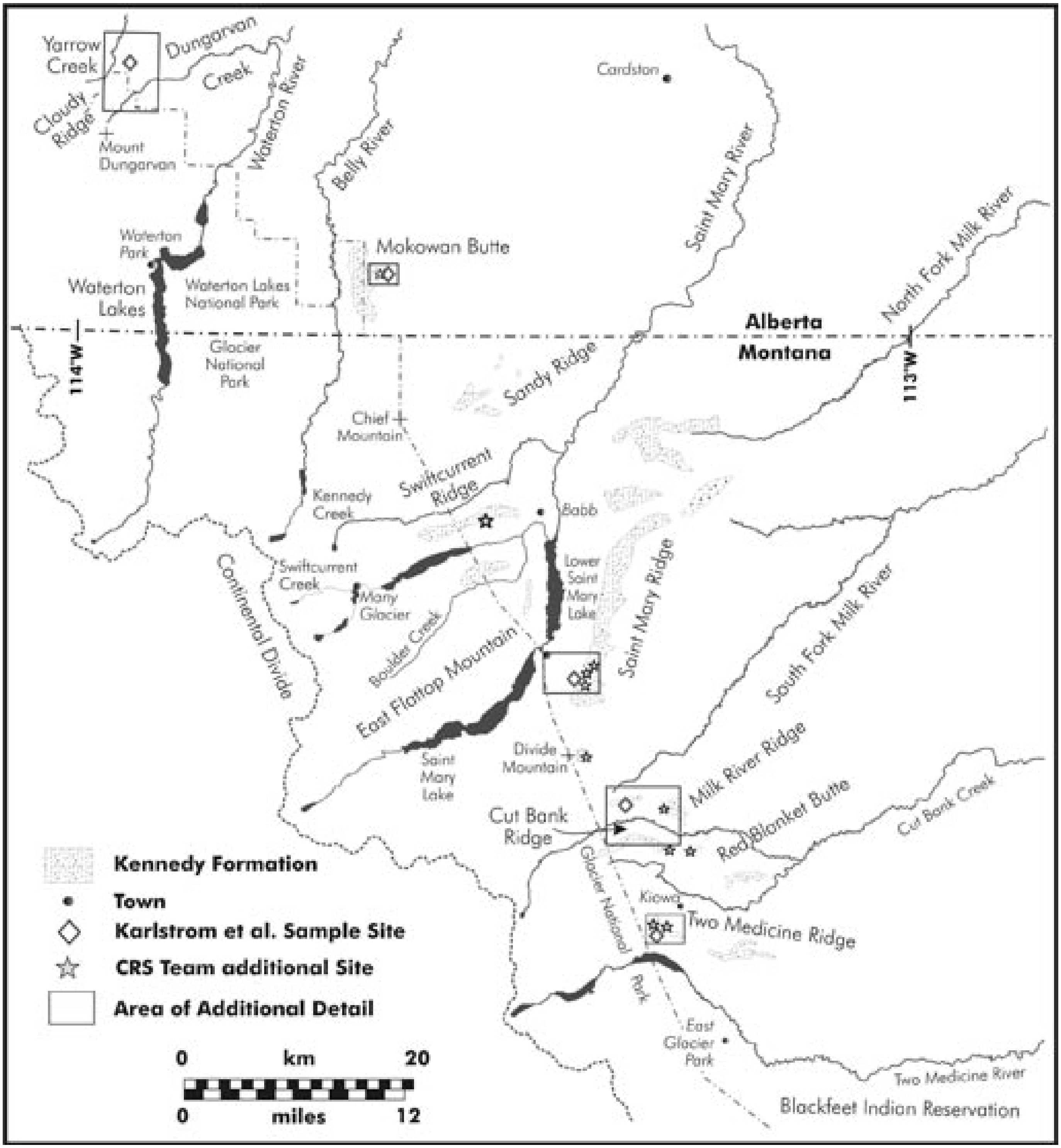

Figure 1. Map of study area.

if soil formation is actively occurring parallel to slopes simultaneously with nearby mass wasting. To resolve this question, we supplemented fieldwork with laboratory investigation.

Laboratory Results

The CRS team collected and submitted 21 samples for laboratory analysis. Vertically oriented thin sections were prepared by Continental Rocktell Services of Calgary, Alberta, and plane polarized and cross-polarized photomicrographs generated. Some samples also were photographed in reflected light and analyzed using scanning electron microscopy backscatter electron imaging and electron diffraction spectroscopy. These images provided information on soil microfabrics, mineralogy, the nature of mineral grains hosting remanent magnetization, the types of physils and their relation to other mineral grains, and evidence (if any) of epigenesis. Control samples were collected from soils developed in nearby stable environments. Some of these analytical data have been presented elsewhere (Klevberg and Oard, 2005).

Sample mineralogy was highly variable. Some samples consisted almost entirely of calcite, others were dominated by quartz and hematite, and some had significant clay content. Some soils that appeared well developed macroscopically appeared less well developed ("less mature") at the microscopic level.

Figures 2 and 3 are thin section images from a well-developed alfisol on Milk River Ridge (MR-1). Figure 2 shows the open structure of the eluvial horizon, with fines bridging sand grains and considerable void space. Figure 3 shows possible clay film development in voids, which corresponds with the macroscopic observation of ferroargillan accumulation indicative of the illuvial B_t (argillic) horizon. However, if the ferroargillans were indicative of long-term pedogenesis in a warmer and moister climate than at present (i.e. paleosols), then chert, feldspars, and lithic fragments should show evidence of epigenesis (chemical weathering resulting in mineral transformation), which is clearly not the case.

Figure 4 is a photomicrograph of a sample of the E horizon from a well-developed alfisol. The sample site (SM-10) is in forested terrain directly above the center scarp on Saint Mary Ridge (Figure 5). This soil is superjacent to (or partially identified with) Karlstrom's (1988) Soil 5. No argillic horizon was encountered. Instead, the percentage of rock fragments increased downward; near the bottom of the pit, the material

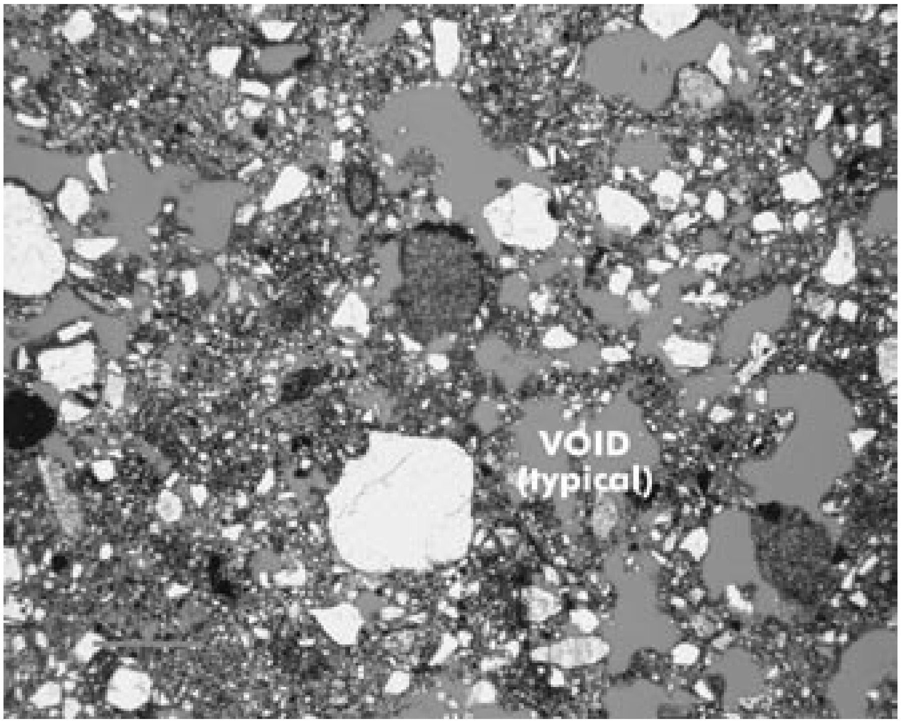

Figure 2. Photomicrograph of eluvial horizon from MR-1.

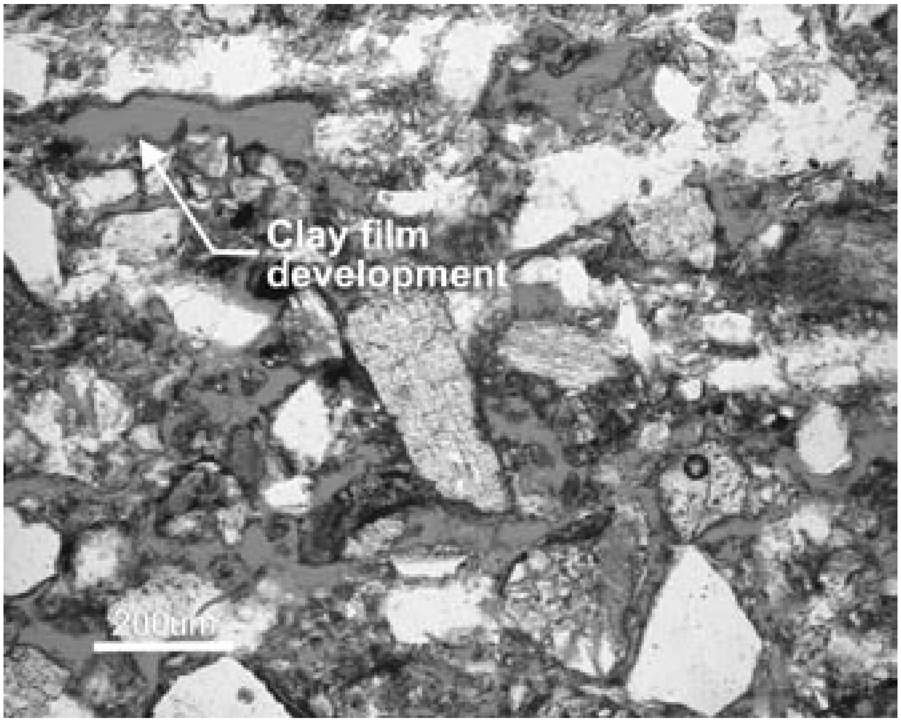

Figure 3. Photomicrograph of illuvial horizon from MR-1.

was similar to packstone, consisting of fine sand of angular limestone fragments with small amounts of physil cement. This indicates soil formation is occurring at this site.

The other samples collected for control purposes provide equivocal evidence for pedogenesis. Figure 6 is a photomicrograph from the B_t horizon at SM-9, at about the same elevation as SM-10 but on the lee side of the ridge (Figure 5). The abrupt boundary between the B_t and C horizons in this soil indicates a geologic rather than pedologic origin. Argillic horizon samples from PH-1, near Mokowan Butte (Figure 7), and SM-7 (Figure 5) exhibit largely "fresh" lithic fragments and lack of clay film development (Figures 8 and 9), again largely controlled by parent material (i.e. geologic origin).

Several of the samples from "paleosol" slopes exhibit evidence of current soil formation. Good clay film development was evident in the B_t sample from PH-4 (Figure 10) on an unstable slope at Pole Heaven, near Mokowan Butte (Figure 7). Evidence of epigenesis is clear at TM-2 (Figure 11), though evidence of translocation is not (Figures 12 and 13). A very small amount of clay film development was evident in images from a sample collected at 90 feet in SM-2 (Figure 5).

"Petrocalcic horizons" are an important factor in the paleosol interpretation. Most of the calcite-dominated zones ("B_k horizons") were observed on Two Medicine and Saint Mary ridges. Pedogenic processes would tend to transform B_k horizons into B_t horizons above the water table in relatively moist climates, and form B_k horizons where leached carbonate encounters the base of the zone of annual wetting, or a less-permeable horizon or aquitard. Evidence of authigenic calcite was observed in thin section images from samples collected in SM-2 and SM-5. Detrital calcite grains, often in a clay matrix and geologic in origin, were observed in images from

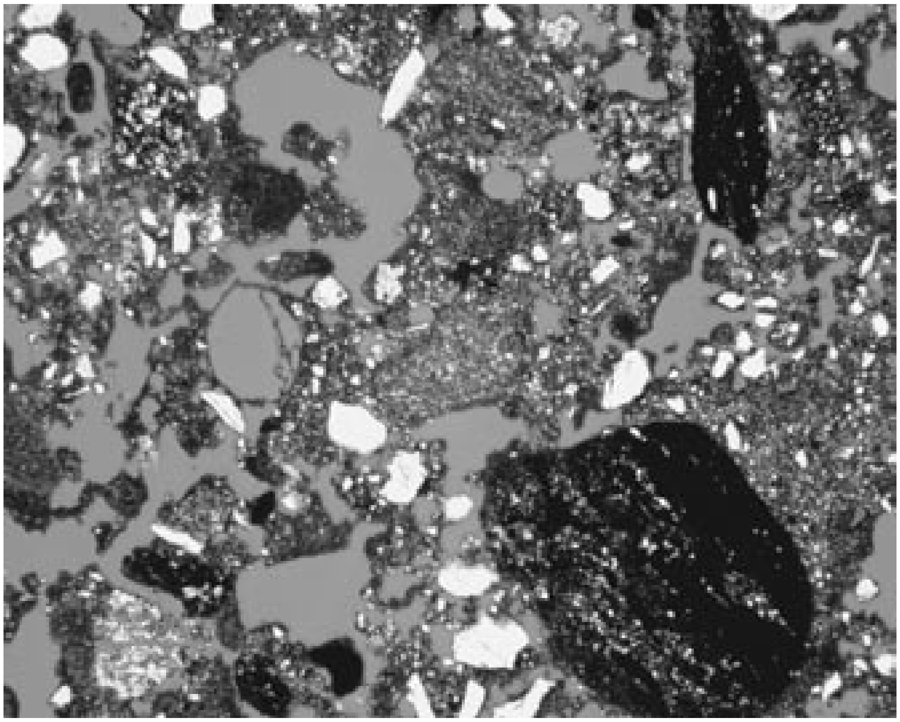

Figure 4. Photomicrograph of eluvial horizon from SM-10.

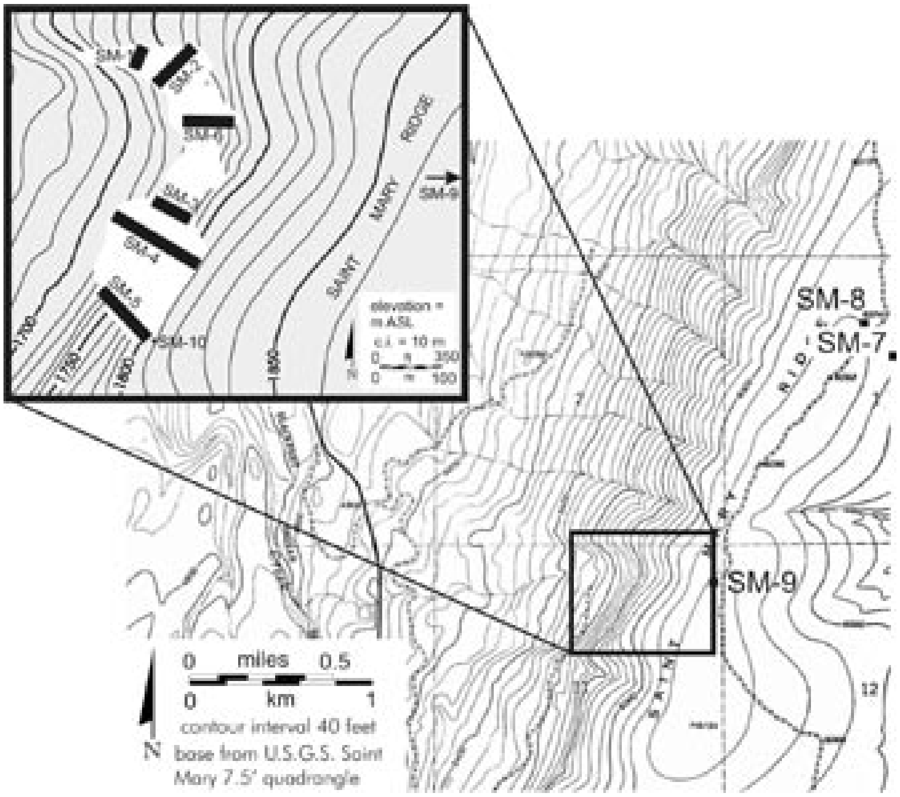

Figure 5. Saint Mary Ridge sample map. Inset shows slide area.

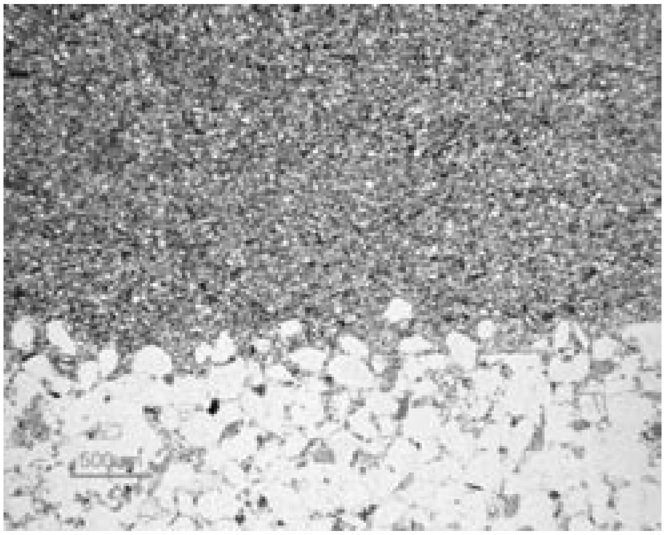

Figure 6. Photomicrograph of B_t horizon from SM-9.

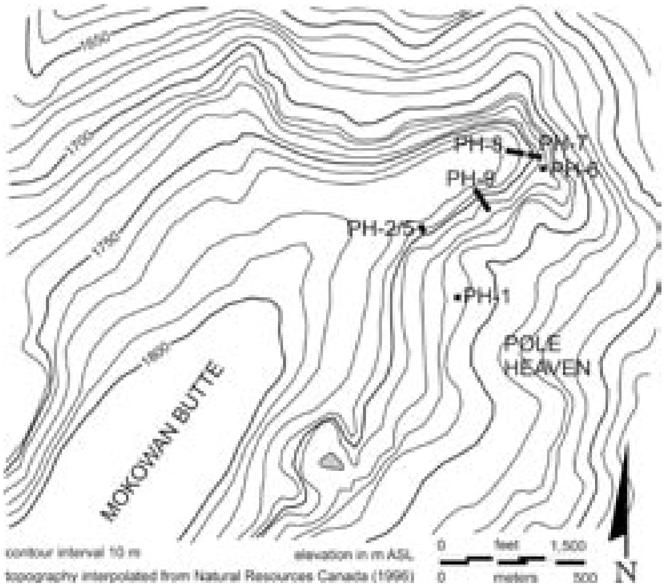

Figure 7. Mokowan Butte sample map.

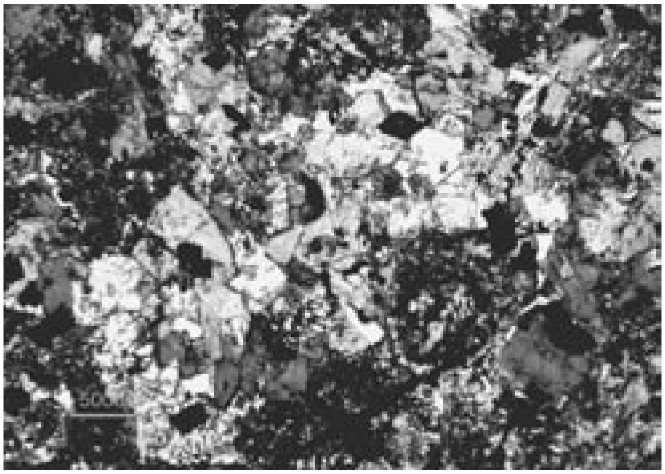

Figure 8. Photomicrograph of B_t horizon from test pit PH-1.

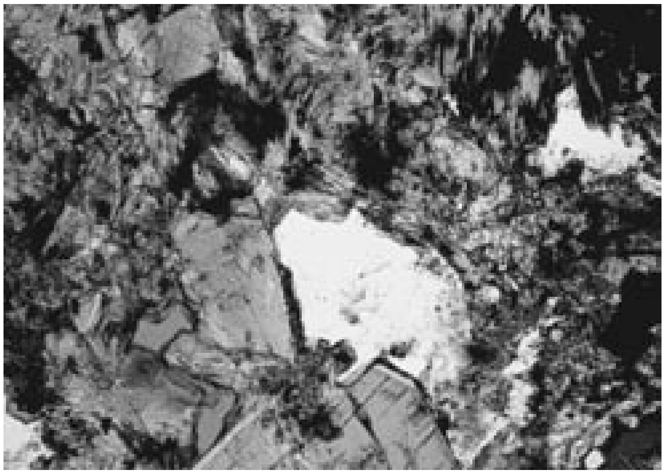

Figure 9. Photomicrograph of B_t horizon from SM-7.

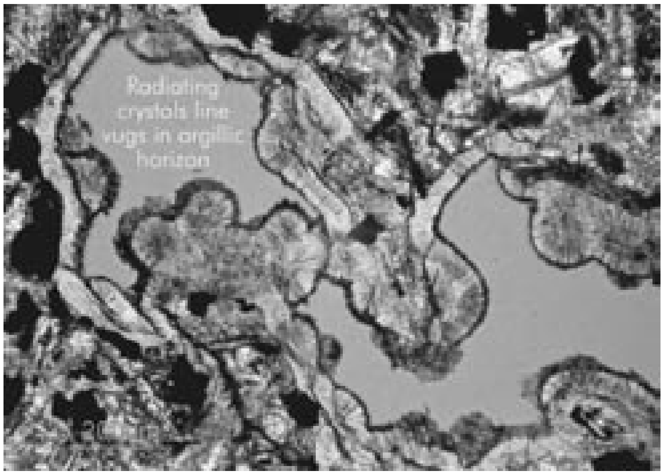

Figure 10. Photomicrograph of B_t horizon from test pit PH-4.

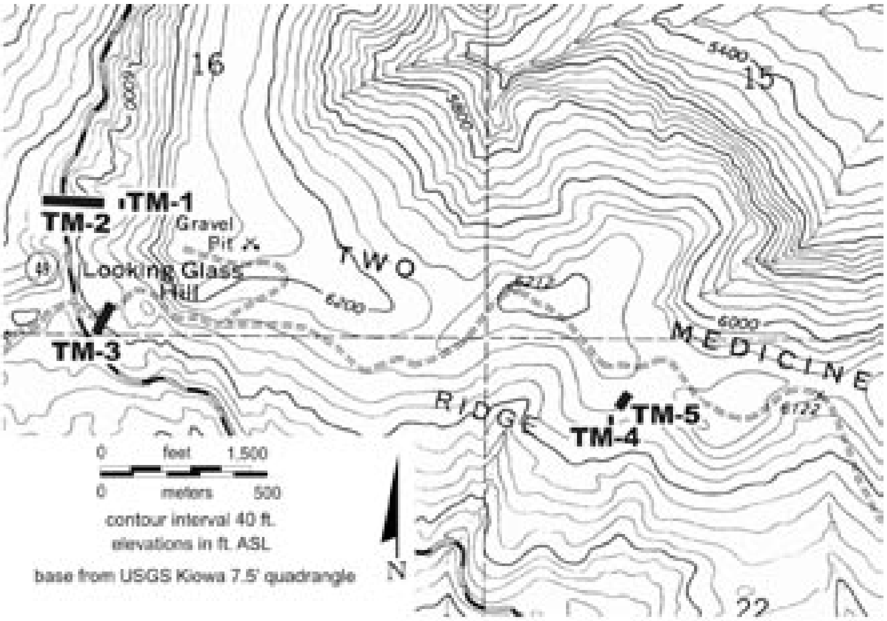

Figure 11. Two Medicine Ridge sample map.

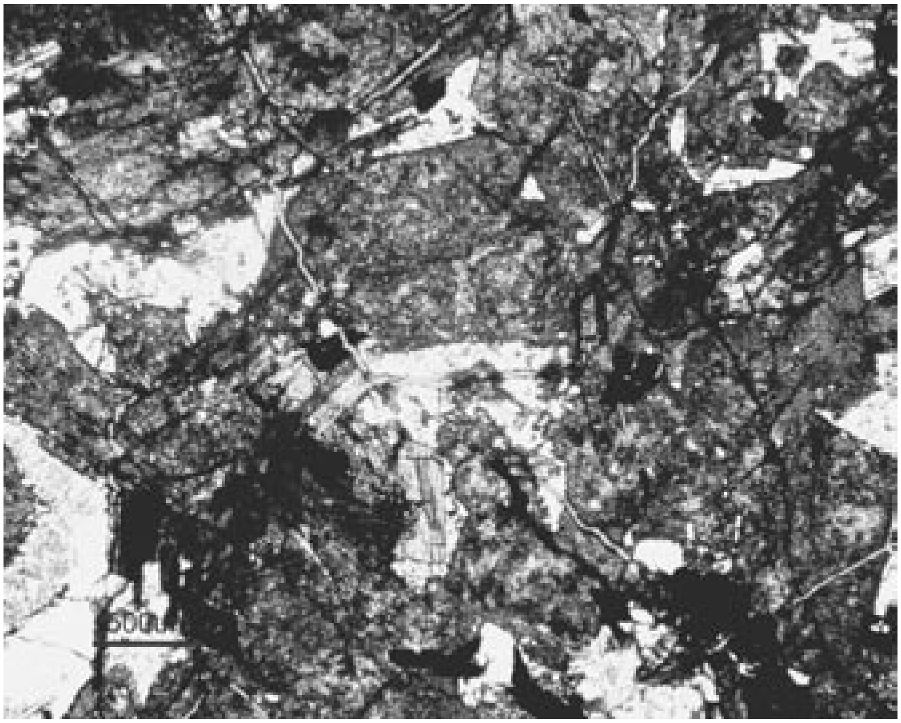

Figure 12. Photomicrograph of A horizon from test trench TM-2.

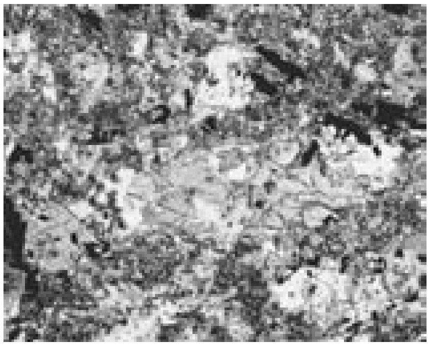

Figure 13. Photomicrograph of B_t horizon from test trench TM-2.

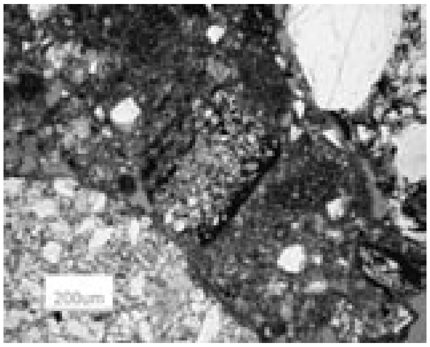

Figure 14. Photomicrograph of B_k horizon from SM-5 at 157 feet.

samples collected in SM-2, SM-4, and SM-5. The sample from SM-5 at 157 feet exhibited both authigenic and detrital calcite (Figure 14). Much of the calcite in images from Saint Mary Ridge samples was fine-grained (75 to 425 µm), well-rounded sand. Most observations from carbonate-dominated zones indicated depositional and diagenetic (i.e. geologic) rather than groundwater (i.e. pedogenic) processes.

The hypothesis of extant pedogenesis in colluvium was not supported by some thin section images. The apparent argillic horizon observed in CR-1 showed fractured, high-physil content aggregates rather than clay film development (Figure 15). Evidence of clay movement was negligible in thin section images from samples of the argillic (B_t) horizon collected in MR-2 at 10 and 20 feet.

Remanent magnetization appears primarily hosted in hematite, most of which is detrital, not authigenic (Kleverg and Oard, 2005). Physils include smectite and illite, occurring primarily as matrix between grains rather than grain coatings, films, or rinds. They probably originated through a combination of

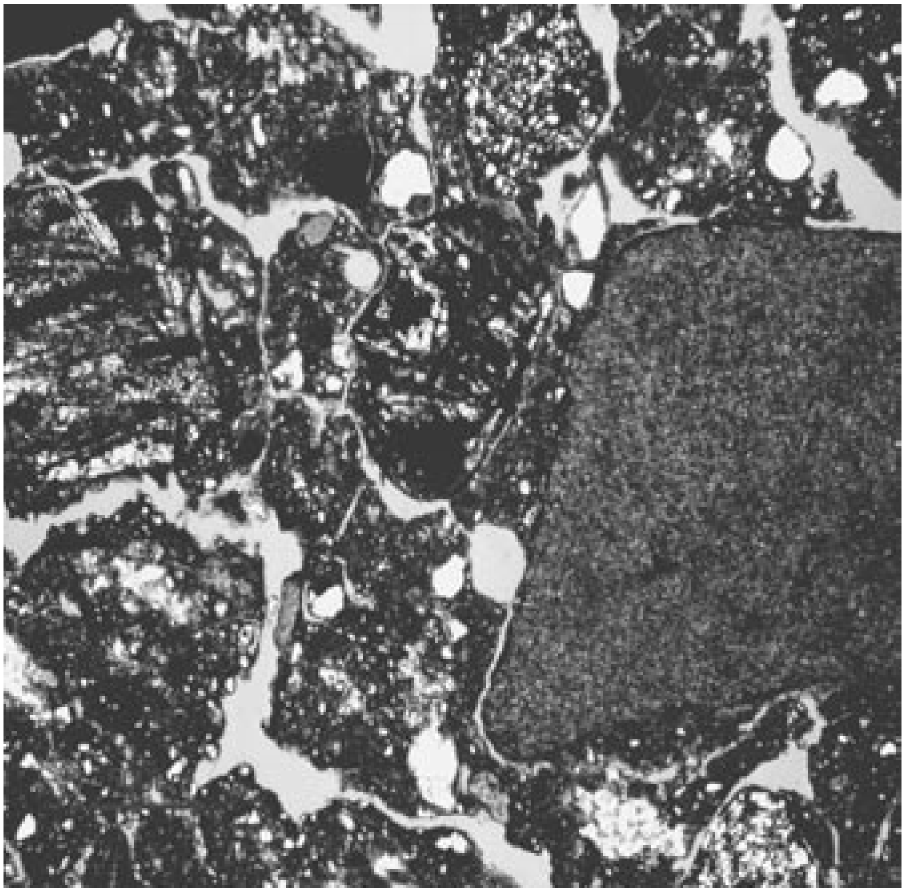

Figure 15. Photomicrograph of argillic ("paleoargillic") horizon from test trench CR-1.

geological processes and translocation (i.e. $\partial^2 S/\partial P \partial t$) during physical weathering (Klevberg and Bandy, 2003a).

Some of the thin section images show evidence of soil formation processes, while others appear to be dominated by geologic factors. Samples from TM-1, TM-4, MR-1, SM-7, SM-8, SM-9, SM-10, PH-1, and PH-4 (see Figure 1) show evidence of pedogenesis. Photomicrographs of samples from landslide scarps (in trenches of both Karlstrom and the CRS team) generally did not show evidence of clay film development or other pedogenic processes; most of these images show characteristics consonant with a colluvial origin. Very little evidence of significant chemical weathering was observed. Thus, while we found ubiquitous evidence of current soil formation, thin section data indicate that soil development in many of the sample locations is rudimentary.

Discussion

Evidence supports a case for either a paleosol interpretation or for a combination of geologic and modern pedogenic processes. Prior beliefs about natural history will likely drive conclusions.

The Case for a Paleosol Interpretation

The argument by Karlstrom and others that the field and laboratory data from the Kennedy Formation indicate the presence of paleosols is supported by evidence of pedogenesis at all of the sites. Argillic horizons are present at several, and these horizons are often relatively thick and deep, suggesting long periods of time or warmer, wetter climates than at present. Secondary minerals and organic oxide complexes (sesquioxides) also imply soil formation. Paleomagnetic studies have permitted separation of paleosol units using magnetochronostratigraphy.

As must be the case in such a natural history interpretation, the conclusions are dependent on several assumptions:

- Rates of current pedogenesis are slow enough to prevent near surface paleosols from being destroyed by ongoing soil formation.
- Rates of current pedogenesis are slow enough to prevent soil formation in landslide scarps that could be mistaken for relict soil features.
- Episodic mass wasting results in sharp landslide scarps with very thin colluvial cover.
- Minimal creep or ongoing mass wasting on the scarps prevents thickening of the colluvial mantle and enables ready removal of the colluvium, producing a clear picture of the backslope profile.
- Carbonate cement is evidence of formation of petrocalcic horizons in soils.
- Magnetic polarity calculated from remanent magnetization measurements accurately reflects the contemporary terrestrial magnetic field (i.e. normal or reversed polarity).
- Magnetochronostratigraphy provides an accurate picture of terrestrial magnetic reversals over time.
- Iron oxide (i.e. rubification) present in the Kennedy Formation is evidence of relatively warm and wet oxidizing conditions conducive to soil formation.

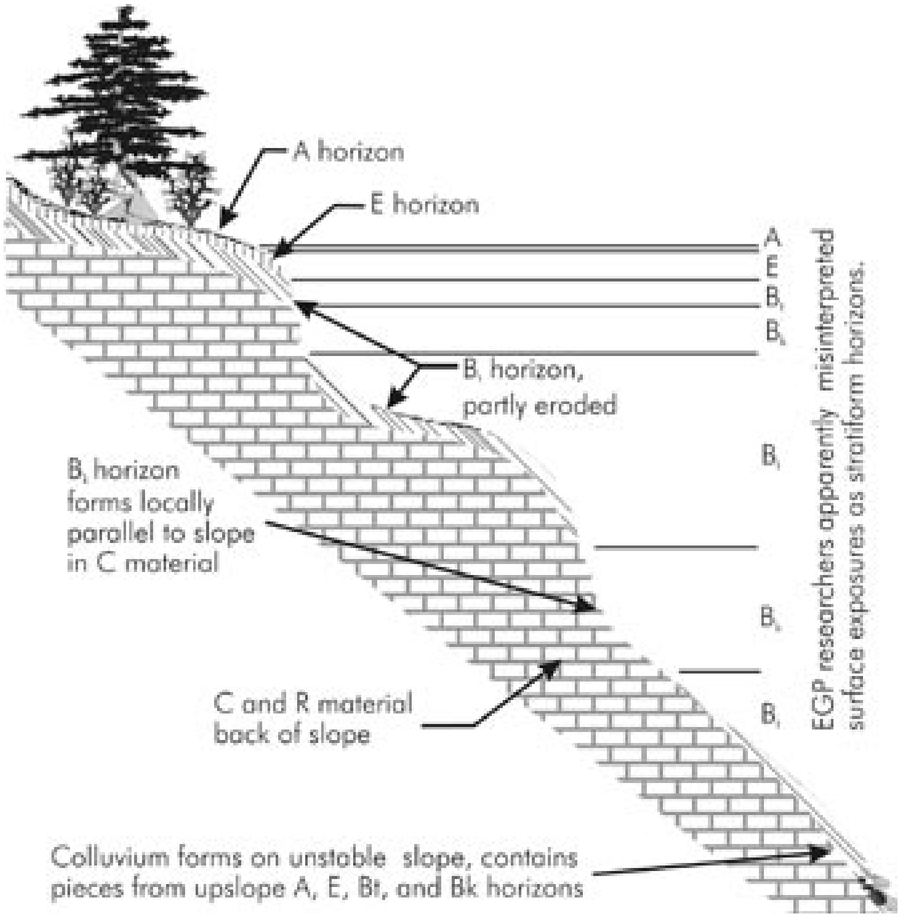
A horizon
E horizon
A
E
B_t
B_k
B_t horizon,
partly eroded
B_t
B_t horizon
forms locally
parallel to slope
in C material
B_k
C and R material
back of slope
B_t
EGP researchers apparently misinterpreted
surface exposures as stratiform horizons.
Colluvium forms on unstable slope, contains
pieces from upslope A, E, Bt, and Bk horizons

Figure 16. CRS team model. While uniformitarians have tended to interpret materials observed on scarps as representing a cross section of strata behind the face, the CRS team believes a combination of mass wasting and ongoing pedogenesis dominates.

If these assumptions are accurate, they bolster the credibility of the paleosol interpretation.

The apparent immaturity of soils from the control locations can be interpreted as evidence for slow rates of soil formation. Interpretation of the Kennedy Formation as a series of paleosols and interpretation of the "immaturity" of control soils as evidence of slow pedogenesis bolsters the old-earth position.

The Case for Ongoing Pedogenesis

Evidence for soil formation in colluvium was evident at nearly all of the sites except where carbonate was adequate to lithify the Kennedy gravel. Rudimentary A horizons were observed on unstable slopes, and better-developed A horizons on more stable slopes. Clay film development and evidence of epigenesis appeared to be related to distance from the slope surface in several locations, though other factors affecting slope stability add to the complexity of the relationship between slope stability and pedogenesis. However, features at all sites correspond equally well with ongoing pedogenesis as they do with relict paleosols.

TM-5 triggered a new model (Figure 16). Based on field evidence, we hypothesized that long-slope pedogenesis occurs contemporary with or alternately with mass wasting, producing bands or bodies of differing earth materials that could be misconstrued as paleosol horizons. Evidence of long-slope soil formation was abundant at MR-2. Even the unstable slope of the Saint Mary Ridge scarp showed that soil formation wages an incessant battle against mass wasting in Kennedy colluvium, as do data from the Pole Heaven and Cloudy Ridge. These observations fit well with our model.

While we are in substantial agreement with EGP (establishment geologic paradigm) researchers about most of the data, we believe their bias toward gradualism has led to an interpretation error, which highlights disagreements between the EGP and DGP (diluvial geologic paradigm) over the importance of different environmental factors and soil forming mechanisms (Klevberg and Bandy, 2003a; 2003b). We emphasize the role of parent material and water movement through the soil, while EGP practitioners stress climate and epigenesis. Our position is supported by high clay content horizons with relatively unweathered lithic fragments and graded bedding. We believe that pedogenesis occurs on even unstable slopes—sometimes outpacing mass wasting, sometimes succumbing to erosion. As a result, various horizons are exposed on the slope surface, sometimes mixed, and readily misinterpreted as superposed horizontal paleosol horizons.

Iron oxide is not evidence of rubification; rather, it was already present in the parent material or introduced during syndepositional processes. Hydrous iron and aluminum oxides impart the warm, bright colors of oxisols, which are believed to form from extreme, protracted weathering in tropical climates (Klevberg and Bandy, 2003a), here interpreted as "rubification." However, our thin section data indicate that minerals that should have weathered long before significant accumulation of the hydrous oxides are still present, often as angular particles. Farther east, quartzite gravels of the Cypress Hills and Flaxville Formations cover the planation surfaces that begin on the east side of Glacier and Waterton National Parks. These gravels are nearly pure quartzite, so the iron did not originate from these clasts. Instead, it appears to have originated in the solutions transporting the sediments, since the gravel clasts exhibit a ubiquitous, uniform patina (Oard and Klevberg, 1998), unlike the pattern expected from solutions leaching down through the sediments. This may also be true for the Kennedy Formation. These same iron oxide colors are also observed in entisols and mollisols on the Kootenai Formation in large parts of Glacier County and elsewhere in Montana (N.R.C.S., 2004), where parent material appears to be the source of the "rubification." Although the Kennedy Formation is not underlain by the Kootenai Formation, iron might have come either from Belt Supergroup rocks or have already been in solution. In either case, evidence for an epigenetic (i.e. pedogenic) source of the iron oxides was not observed.

The Case against a Paleosol Interpretation

All of the assumptions listed above in support of the paleosol interpretation are suspect.

- Rates of soil formation are often much higher than uniformitarian predictions (Klevberg and Bandy, 2003a; 2003b).
- Slow pedogenesis is essential to the hypothesis that landslide scarps provide an accurate cross section of buried horizons. Slope-parallel soil formation could mask the buried horizons.
- Colluvial cover and soil creep can obscure any cross section of buried horizons in landslide scarps.
- Thin section data indicate that the majority of calcium carbonate in the sampled sections is detrital and not related to pedogenesis.
- Thin section data indicate that paleomagnetic data from sampled locations may well reflect something other than the contemporary terrestrial field. Apparently normally and reversely magnetized samples may not reflect terrestrial reversals.
- Magnetochronostratigraphy includes many uniformitarian assumptions that may lead to distortion or misinterpretation of paleomagnetic data (Klevberg and Oard, 2005).
- Iron oxide in the Kennedy Formation appears to be geologic in origin, not pedogenic.

Most of the data therefore appear at variance with the paleosol interpretation, and the evidence essential to the paleosol position seems dependent merely on uniformitarian assumptions. These data are more readily explained if a complex geologic origin is assumed rather than a uniform pedogenic history.

Uniformitarian training often biases researchers toward single-sequential thinking in earth history studies. In reality, most geological deposits are probably polygenetic, most earth processes are probably complex, and our interpretations of earth history need to reflect these realities. Single-sequential thought patterns may have hampered previous researchers in understanding the important role of current pedogenesis. Their commitment to uniformitarianism has certainly been detrimental.

Is the Kennedy "Drift" Really Glacigenic?

Four decades of research have upheld the opinion of Whitcomb and Morris (1961, p. 299):

> In general, we feel the conclusion may be justified that the supposed earlier, weathered tills and other soils beneath the last glacial deposits really represent either deposits made in the last stages of the Deluge or else deposits made in the early stages of the oncoming glaciation.

Klevberg and Oard (2005) noted that arguments for a glacial origin of the Kennedy Formation are weak, and the data are more readily explained by processes expected during late diluvian and early postdiluvian time: mass wasting, traction currents, and the fluid transitional states between them. All these are capable of explaining striated clasts, rounded to angular clasts, and the often imperceptible transition between the equivocal parts of the Kennedy Formation and the clearly fluvial parts farther east.

Do Kennedy "Paleosols" Record Magnetic Reversals?

Magnetostratigraphy is essential to the distinction of some of the paleosol units described by EGP researchers (Karlstrom, 1988). However, the claim for an accurate record of terrestrial magnetic field reversal in Kennedy Formation sediments is underwhelming at best (Klevberg and Oard, 2005). At this point, we neither affirm nor deny the veracity of the paleomagnetic data collected by Karlstrom and others from the study area, but only question the adequacy of these data in the light of the variables summarized below.

Thin section images show that the hematite hosting the remanent magnetization is primarily detrital, recording the orientation of each grain at deposition rather than the orientation of the earth's magnetic field, a common problem in paleomagnetic studies of sedimentary rocks (Tarling, 1983). Thus, some of the results used by EGP researchers in support of magnetostratigraphic interpretations (Karlstrom, 1988) are probably not valid paleomagnetic data.

Isothermal remanent magnetization (IRM) can affect areas where thunderstorms are frequent (Butler, 1992), such as our study area. While Karlstrom and Barendregt (2001) mention possible "resetting" by lightning, IRM may still be a factor in some of their samples. Step-wise demagnetization is intended to account for IRM, but it is important to observe sampling locations to ascertain the likelihood of lightning strikes (Tarling, 1983). Viscous remanent magnetization (VRM) is similar but occurs over time in a logarithmic manner (Strangway, 1970), thus tending to dampen reversed paleomagnetism. It may be necessary to obtain a relatively large number of samples (at substantial time and expense) to reduce this uncertainty.

Chemical remanent magnetism (CRM) can also distort results, and the magnetite orientation that occurs when magnetite oxidizes to hematite has not been determined,[1] though the opposite reaction does acquire the contemporary field orientation, and it is likely this is generally the case with all similar reactions (Hailwood, 1989). Oxidation of magnetite or ilmenite to hematite or titanohematite appears to be occurring in sample SM5-157 (Klevberg and Oard, 2005). Self-reversal has been observed (remanent magnetization *opposite* to the contemporary magnetic field) in titanohematite, a 50%$_{\text{mol}}$ mixture of ilmenite and hematite (10% titanohematite + 90% hematite) and in the formation of hematite from maghemite (Merrill et al., 1998). Obtaining accurate paleomagnetic data requires collecting multiple samples from each horizon, very carefully located (Hailwood, 1989).

Thus, while Karlstrom and others apparently have done careful work in collecting samples for paleomagnetic analysis, many pitfalls from a complex geologic history could lead researchers to false conclusions about the history of Earth's magnetic field and the time of formation of various horizons. Indeed, magnetochronostratigraphy is based on evolutionary and other assumptions beyond the pale of science (Hailwood, 1989; Merrill et al., 1998), and erroneous assumptions compound errors during analysis.

Were the Kennedy Formation "Paleosols" Ancient Soils?

The argument for long periods of time for paleosol formation hinges on their interpretation as ancient soils. Evidence of ongoing soil formation was observed at all of the sites described by EGP researchers, as was evidence of slope instability. These sites do not reveal a cross section of superposed soil profiles, but they show soil formation within active colluvium. Mass wasting occurs as creep, sloughs, slumps, and slides. Sometimes it is episodic and infrequent enough to permit substantial soil formation, while at other locations slope instability prevents a high degree of development in soils. When soils develop, they are often subsequently carried downslope by mass wasting events, mixing with the colluvium.

Observed soil formation is primarily *parallel* to the slope, not to the horizontal, except at the top of the slopes, where conditions favorable to soil formation tend to produce well-developed alfisols. Soil development on scarps and at other locations (Klevberg and Bandy, 2003b; Klevberg et al., 2003) indicates rapid pedogenesis—a few centuries. The extent of epigenesis observed in thin sections is minimal, indicating that these soils are very youthful relative to the nonlinear curve describing pedogenesis (Klevberg et al., 2003). Disseminated iron oxide appears to be syngenetic, not authigenic, which is not surprising based on formations farther east (Oard and Klevberg, 1998) and is thus not indicative of soil formation, let alone paleoclimate. Finally, the probability of preservation of exposed paleosols is low.

Do These Deposits Really Indicate the Passage of Long Periods of Time?

Much of the argument for long ages hinges on the paleosol interpretation, since many geologic processes operate catastrophically and require very little time. Such was probably the case for the Kennedy Formation (Klevberg and Oard, 2005). Pedogenic arguments, especially those requiring great periods of time, often are equivocal (Klevberg and Bandy, 2003a; 2003b; Klevberg et al., 2003).

Physils

At least some of the physils observed in the alleged paleosols are present in Belt Supergroup source rocks or may be explained in non-pedogenic ways (Karlstrom, 1988). In contrast, sesquioxides are not typical of any known geologic environment and appear indicative of soil formation. Karlstrom (1988, p. 158) described a spodic horizon "superposed into" a "relict paleosol" at the surface of Saint Mary Ridge. This corresponds with our observations of some of the soils between SM-9 and the landslide scarp (Figure 5). However, this surficial "relict paleosol" (and the others claimed for the study area) should not have survived long enough to be recognizable, being subjected to modern pedogenic processes (Klevberg et al., 2003). Also, the "argillic" horizon subjacent to the spodic horizon also may be of geologic rather than pedologic origin.

Carbonates

Also significant is Karlstrom's (1988) observation that dolomite is abundant in some of the "petrocalcic horizons" he sampled. While dolomite can be more soluble than calcite in some groundwater environments (Raymond, 1995), experiments with limestone and dolostone for treating contaminated surface and groundwater indicate that relatively pure dolostones are much less soluble than limestones or calcareous dolostones (Letterman et al., 1987). Groundwater in both vadose and saturated zones is more likely to dissolve calcite than dolomite, so abundant dolomite probably indicates a depositional environment much different from the present or a dolomite-rich parent material. Dolomite may dominate in seawater or mixed waters, especially warm water with a minimum of 10% seawater (Raymond, 1995, pp. 309–311). Dolostone and magnesian limestone are present in the Altyn Formation, which outcrops along the east side of Glacier National Park and as far east as Divide and Chief Mountains (Ross, 1959), the inferred source area for the Kennedy Formation. Thus, while the ratio of dolomite to calcite is likely to be low if deposited from groundwater, it could be much higher if syngenetic with the Kennedy Formation, as these data indicate.

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[1] Strangway (1970, p. 49) discounts the importance of CRM on the basis of uniformitarian assumptions, which, of course, undermines the credibility of his conclusion that CRM by itself is not likely to significantly alter the direction of overall remanent magnetism.

Iron Oxides

Elevated iron (relative to the majority of rocks and unweathered sediments) is also typical of parts of the Altyn Formation (Ross, 1959) as well as much of the Belt argillite in the Kennedy Formation. Elevated iron and aluminum is typical of highly weathered sediments, but lack of silica depletion in samples collected from Two Medicine Ridge (Karlstrom, 1988) indicates that iron enrichment rather than silica depletion is responsible for relatively high iron oxide concentrations in the alleged paleosols. This also corresponds with our observations of Flaxville surface (Bench No. 1) deposits farther east (Oard and Klevberg, 1998), where the iron oxide is very likely syngenetic.

Rates of Pedogenesis

Evidence shows that soil formation occurs much more rapidly than envisioned by EGP researchers (Klevberg and Bandy, 2003b; Klevberg et al., 2003), and any practicing soil scientist would recognize ongoing pedogenesis in the study area. While soil formation is a slow process in comparison to a human life span, it is not slow in the way most geologists think of time. For example, during the Dustbowl of the 1930s, silt and fine sand often were deposited to depths of a few meters, burying fences and other structures that make identification of the previous ground surface easy. Unlike most alleged paleosols, A horizons are typically present in these buried soils. Pedogenesis often is significant in these deposits. Well-developed alfisols such as those observed in this study can readily develop in even a comparatively cool and dry climate in the space of several centuries. This would be still more likely for the permeable Kennedy Formation, though it could be expected even in finer grained materials (Klevberg and Bandy, 2003b; Klevberg et al., 2003).

Challenges in Investigating Possible Paleosols

The only way to definitively determine whether subhorizontal soil horizons exist in the subsurface would be to excavate or drill a relatively undisturbed vertical surface or sample. This would be extremely difficult in the coarse material of the Kennedy Formation. Only in the top section of the Cloudy Ridge site was the colluvium shallow enough (due to carbonate cementation) to permit adequate removal using Karlstrom's method, and it did not exhibit superposed soils. If these geologic units were not soils, then the argument for long periods of time evaporates. While soil formation can be much more rapid than EGP adherents commonly recognize, geologic processes can be—in many cases must have been—even more rapid. The size of water-rounded boulders in the Kennedy Formation implies strong currents, as do the gravels on the Flaxville surface and other surfaces (Oard and Klevberg, 1998).

Stratigraphy

In addition to the rapid formation of soils, the traditional argument also hinges on stratigraphic correlation. Suppose ten paleosols are superposed, each of which required a thousand years to form. The total time required would be in excess of ten thousand years, which would push it considerably beyond the biblical date for the Deluge. But the argument for superposition relies on pedostratigraphic correlation, which offers many pitfalls (Klevberg, 2000; Klevberg et al., 2003). Pedostratigraphy is frequently tied to magnetostratigraphy, with its own weaknesses (Klevberg and Oard, 2005).

Our examination of the study area (including Karlstrom's sites) convinced us that his correlations are dubious. Even the three "paleosols" at Saint Mary Ridge are not apparent at any scale; indeed, the fabric appears at variance with both the paleosol designations and a pedogenic origin (Klevberg and Oard, 2005). Anticreationists have it backwards: pedostratigraphy cannot cast doubt on biblical history when the preponderance of our data cast doubt on pedostratigraphy.

A Diluvial Interpretation of Kennedy "Paleosols"

While the paleosol interpretation of EGP researchers for the Kennedy Formation clearly contradicts the timescale of the Bible, its assumptions are highly suspect. The diluvial position does not deny the existence of paleosols (Froede, 1998; Klevberg et al., 2003), but the paleosol interpretation of the Kennedy Formation is not well supported. In particular:

- Field observation indicated ongoing soil formation at nearly all of the sites.
- Current pedogenesis can occur roughly parallel to slopes and becomes quite complex where unstable colluvium mixes soil materials downslope.
- Microscopic evidence supports a geologic origin for features that could be either geologic or

pedologic based on macroscopic evidence, including apparent argillic and petrocalcic horizons, pervasive iron oxides, carbonate species and distribution, and physil species.

- The apparent low degree of development of most of the soils can be interpreted as evidence for slow pedogenesis over vast periods of time. Alternatively, relatively "immature" soils may result from parent material subjected to the action of groundwater and physical weathering (Klevberg and Bandy, 2003a). Climate and epigenesis may be less important than EGP researchers have assumed. The time during which soil formation has occurred also may be much less than EGP researchers have envisioned.
- Paleomagnetic data from the Kennedy Formation must be viewed with caution, are subject to several possible interpretations, and provide an inadequate basis for stratigraphic correlation.

Conclusion

In general, we think that soil formation is effectively occurring in the Kennedy Formation, especially under forest cover. Unstable slopes in the study area are dominated by colluvium and may be subject to sloughing and creep; they do not provide unambiguous evidence for buried soil horizons. The Kennedy Formation exhibits features of both mass wasting and fluvial transport. While the surface may have been modified by glaciation, the formation as a whole is probably diluvial in origin. Rates of pedogenesis are adequate to explain the presence of the observed soil horizons within the biblical timeframe, even allowing for a postdiluvial ice age.

Since creationists have done little to investigate the scientific veracity of paleomagnetic techniques and conclusions, and since these studies are important to paleosol investigations, we suggest this as an area for extended research. Also, while pedostratigraphic correlation between Two Medicine Ridge, Milk River Ridge, Saint Mary Ridge, Mokowan Butte, and Cloudy Ridge (Figure 1) has been called into question by this study, an even more direct means of studying the veracity of the EGP correlations would be to investigate the landslide scarps on Saint Mary Ridge north and south of the scarp studied by Karlstrom and included in this study. Additional geochemical and physil identification studies could be undertaken. If these are performed, test pits or trenches for both test and control samples will be vital to a proper interpretation of the results. Pedostratigraphic analysis must be performed independently of magnetostratigraphic and other stratigraphic methods and results integrated afterward. Studies of alleged paleosols in other topographic and climatic settings could provide useful comparisons to this study.

Acknowledgements

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Glossary

aquitard: a zone of relatively low permeability that hinders the movement of groundwater.

authigenic: said of minerals that form in place, often in pores in rocks, during diagenesis, typically as precipitates from aqueous solutions such as groundwater.

diagenetic: resulting from diagenesis, i.e. the changes occurring in a sediment after deposition but at near-surface conditions of temperature and pressure.

detrital: materials derived by physical weathering followed by transport to their place of deposition.

epigenesis: replacement of existing minerals or formation of new minerals under conditions of temperature and pressure that characterize the near-surface environment.

ferroargillan: physils containing high concentrations of iron or bonded to iron oxides; often limonite, a mixture of iron oxides and iron hydroxides, is disseminated in the physil mass.

glacigenic: having its origin in glacial processes (also spelled *glaciogenic*).

magnetostratigraphic: a conceptual scheme for the organization of units of earth materials (possibly demonstrating temporal relationship) based on remanent magnetic properties.

pedostratigraphic: stratigraphic correlation of units of earth materials based on soil profiles.

rubification: oxidation of iron in a sediment or soil horizon, resulting in a redder color; often used as an indicator of weathering in warm, moist conditions, though this is disputed (Klevberg and Bandy, 2003b, p. 110).

sesquioxides: oxides (typically of iron) that are more highly oxidized than other species (e.g. ferric oxide as opposed to ferrous oxide) and that typify soil horizons where leaching in the presence of organic acids is occurring.

syndepositional: occurring as part of the depositional process; contemporaneous with deposition.

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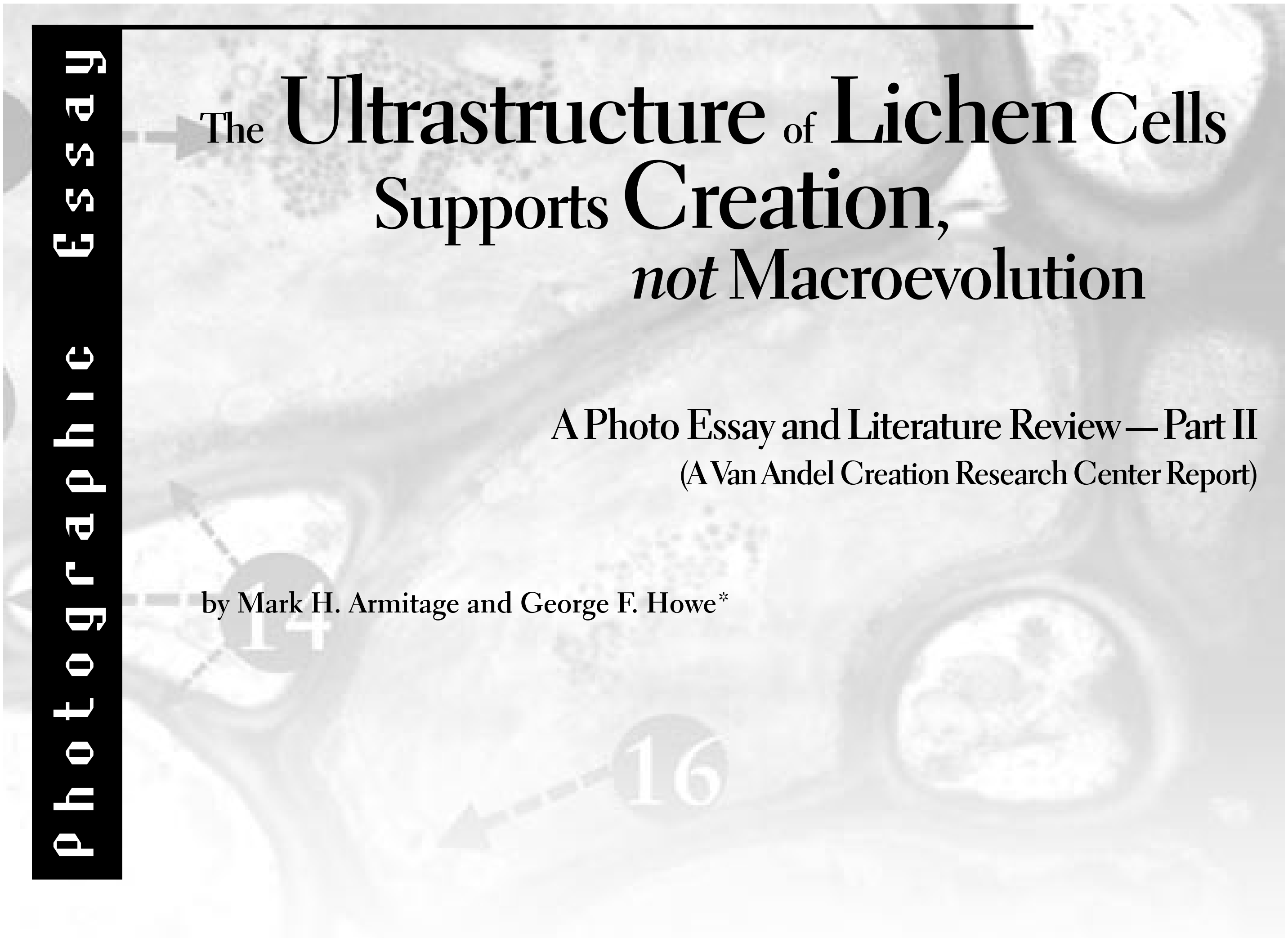

Photographic Essay

The Ultrastructure of Lichen Cells Supports Creation, *not* Macroevolution

A Photo Essay and Literature Review—Part II

(A Van Andel Creation Research Center Report)

by Mark H. Armitage and George F. Howe*

Introduction

Lichens are a life-form composed of fungi growing in symbiotic union with algae (Howe and Armitage, 2002). Lichen pigments play many important physiological roles, while their brilliant colors provide considerable aesthetic enjoyment (Howe and Armitage, 2003). The versatile array of lichen asexual reproductive bodies and the other fascinating features of the lichen upper surface have been studied by using scanning electron photomicrography (Armitage and Howe, 2004). Lichen algae and fungi are woven together forming "tissues" that resemble the tissues of unrelated "higher plants" in a general fashion (Armitage and Howe, 2006).

Our previous article (Armitage and Howe, 2007) contains figures showing detailed cross sections of various lichen fungi and alga. This current paper provides more photomicrographs of the cells of lichen fungi (mycobionts) from various lichens, and figure 20 is of a lichen algal cell (phycobiont). We show that lichen cellular ultrastructure yields evidence favoring intelligent design and direct creation. The Bible states that it is possible to gain knowledge about the Creator by studying His work (Romans 1:20). Based on this concept, we hope that readers will learn more about God through the study of lichens, which we believe He created.

Methods

The methods we used in sectioning the lichens and securing the electron photomicrographs are the same as those discussed in previous papers (Armitage and Howe, 2004; 2006).

Lichen Ultrastructure

The Cell Wall Supports the Design Model

There is a magnificent complexity apparent in the layers of fibers present in the cell walls of fungi, algae, and plants.

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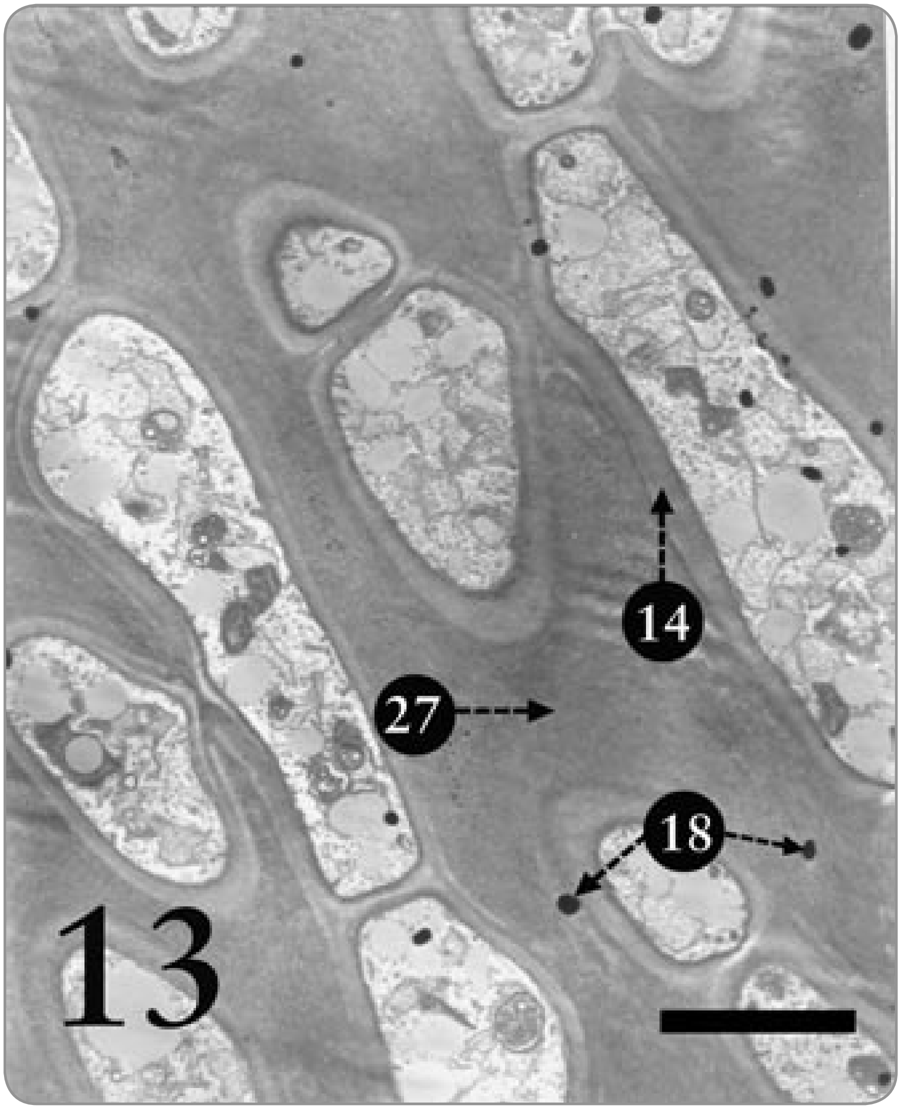


Figure 13. Lichen fungus cells in the medulla region of *Candelariella* sp. The hyphae are suspended in an extracellular matrix, which has been formed by the mycobiont hyphae (27). Cells here may be sexual structures in an early stage. The cell wall is (14). The magnification is 12,000X; the scale bar is 40 micrometers.

Mycobiont cell walls contain chitin, glucans, glucosamine, and amino acids (Ahmadjian, 1993). Animal cells generally lack cell walls, and since animal cells require flexibility, the absence of cell walls appears itself to be an intelligent design for them. Cell walls can be observed in most of our figures, where they are labeled "14." A thick extra cellular matrix suspending mycobiont cells in the medulla is labeled "27" on Figure 13.

The cell wall is able to increase in length and thickness as the cell grows larger. This is an amazing phenomenon because cell walls are composed of fibers, which are themselves nonliving. This would be somewhat like a human shoe, which after being fitted to the foot of a small child, could maintain the same thickness and yet continue to expand as that child's foot enlarges to its adult size (see Howe, 1966, pp. 107–108).

An ingenious feature of cell walls in the lichen mycobionts is that they are relatively thin in mycobiont cells of the algal layer. Fungal cells within the algal layer need to absorb photosynthate molecules from nearby phycobiont cells. But walls of fungi in the medulla are much thicker in this tissue where structural support for the lichen is needed, a design topic we discussed at some length in a previous paper (Armitage and Howe, 2006). Intelligence is evident in fungus cell walls because: "Hyphae of the medulla and cortex have an outer and inner wall layer, while those of the photobiont zone have only one layer" (Ahmadjian, 1993, p. 19). This two-layered structure of mycobiont cell walls in the medulla has been demonstrated by other workers but is not obvious in our figures. Two layers appear to be a design for strength in the medulla and cortex tissues but one layer is more suitable for transmission of photosynthate in the algal zone.

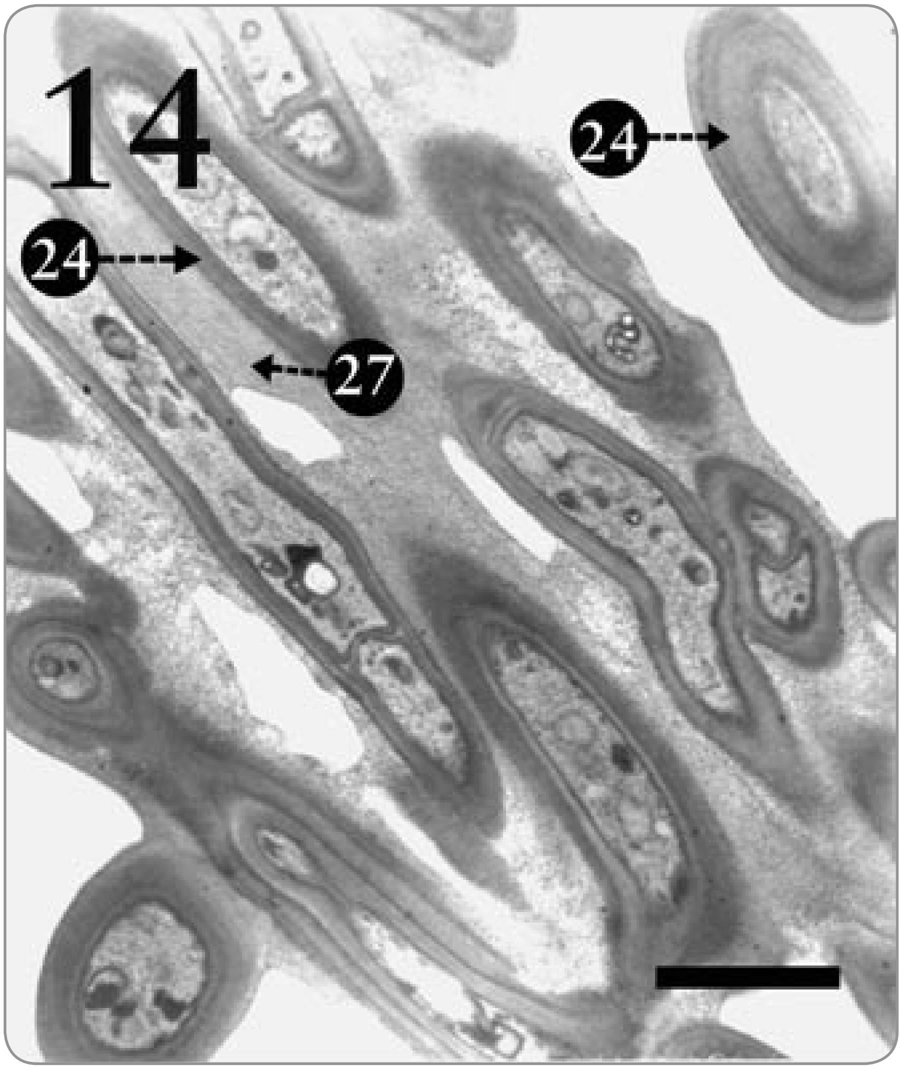


Figure 14. A slanted section crossing through the medullary mycobiont hyphae of *Pleiopsidium chlorophana*: magnification 9,000X with a scale bar of 50 micrometers. Hyphae in the medulla have thick walls (24) and a thick matrix between the cells (27), both of which lend strength to this supporting tissue.

This propensity to produce either thin or very thick cell walls must depend not only on the genetics of the mycobiont, but somehow must be mediated by the presence of the algae. Another design feature is that lichen medulla tissue possessing numerous hyphae usually will have cell walls that are thin, whereas another medulla with few hyphal layers generally has thick hyphal cell walls. Therefore, "by this distribution and differentiation, the stability of a thallus is guaranteed" (Peveling, 1973, p. 165). We think that balanced wall differences like these demonstrate God's handiwork.

The major difference in hyphal cell wall thickness in the algal zone versus the medulla can be seen by comparing fungus cell walls of the same lichen species (*Xanthoparmelia sp.*) from its algal zone (Figure 7, number "14m" in Armitage and Howe, 2007) with those from its medullary tissue (Figure 10, number "24" in Armitage and Howe, 2007). Although the magnification in Figure 10 is slightly greater than Figure 7, both photographs are of the cell wall of the same lichen, and it is obvious that cell wall thickness is much greater in the medulla than in the algal layer. While not promoting creation or intelligent design, Ahmadjian (1993) wrote two sentences about the balance of cell wall properties, which enables lichens to function properly:

> The walls have to be strong enough to withstand the drying and wetting cycles of the thallus and to facilitate these cycles by losing and imbibing water quickly. In addition, they have to be flexible in order to interface with (appressorial) and penetrate into (haustorial) cells of the photobiont. (p. 17)

It cannot be shown that neo-Darwinian evolution furnished these well-adapted cell wall features.

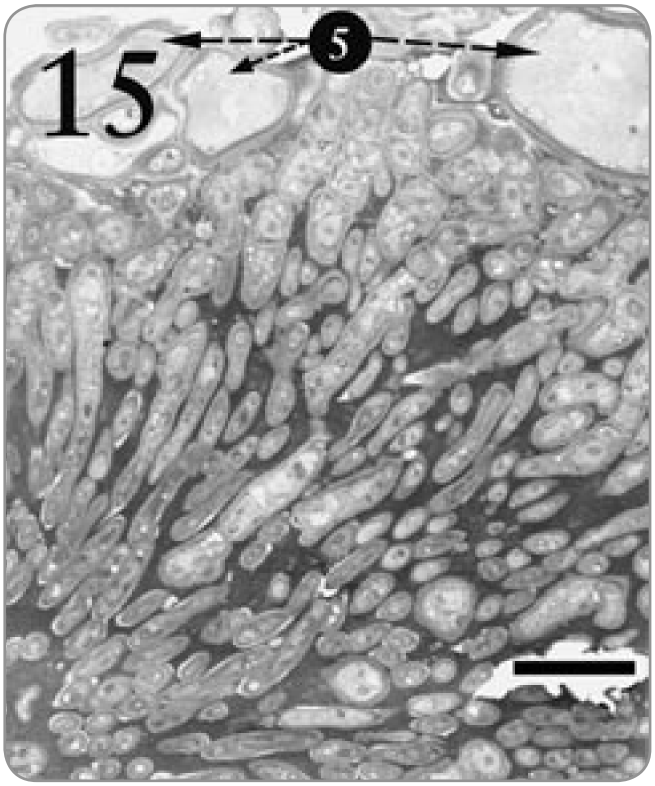


Figure 15. A section of a developing apothecium, which is pushing upward through the algal layer of the lichen *Xanthoparmelia sp.* 5,000X magnification and scale bar is 150 micrometers. These hyphae are inside item 5 of Figure 1. They are fungus filaments in a developing apothecium and they were growing upward, pushing their way through the phycobiont cells (5) of the algal layer. Ultimately, they will form a cup-shaped apothecium on the lichen's upper surface. The apothecium contains asci [spore sacs] in which ascospores are produced, spores that can germinate after liberation, as has been shown in culture experiments.

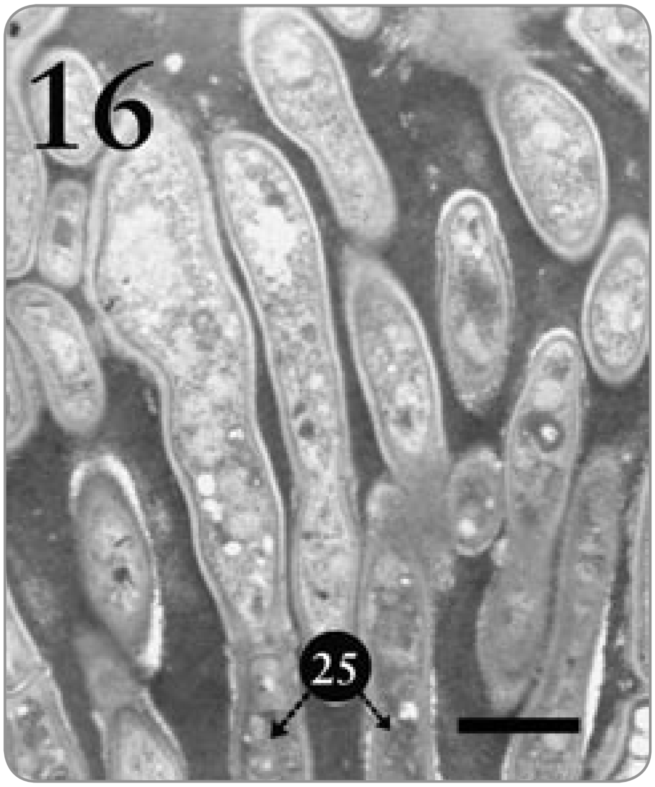


Figure 16. A closer view of cells in the developing apothecium of *Xanthoparmelia sp.*: magnification of 11,000X; the scale bar is 90 micrometers. Items labeled (25) are myelin-like structures.

The Developing Ascocarp Moves Upward in the Thallus

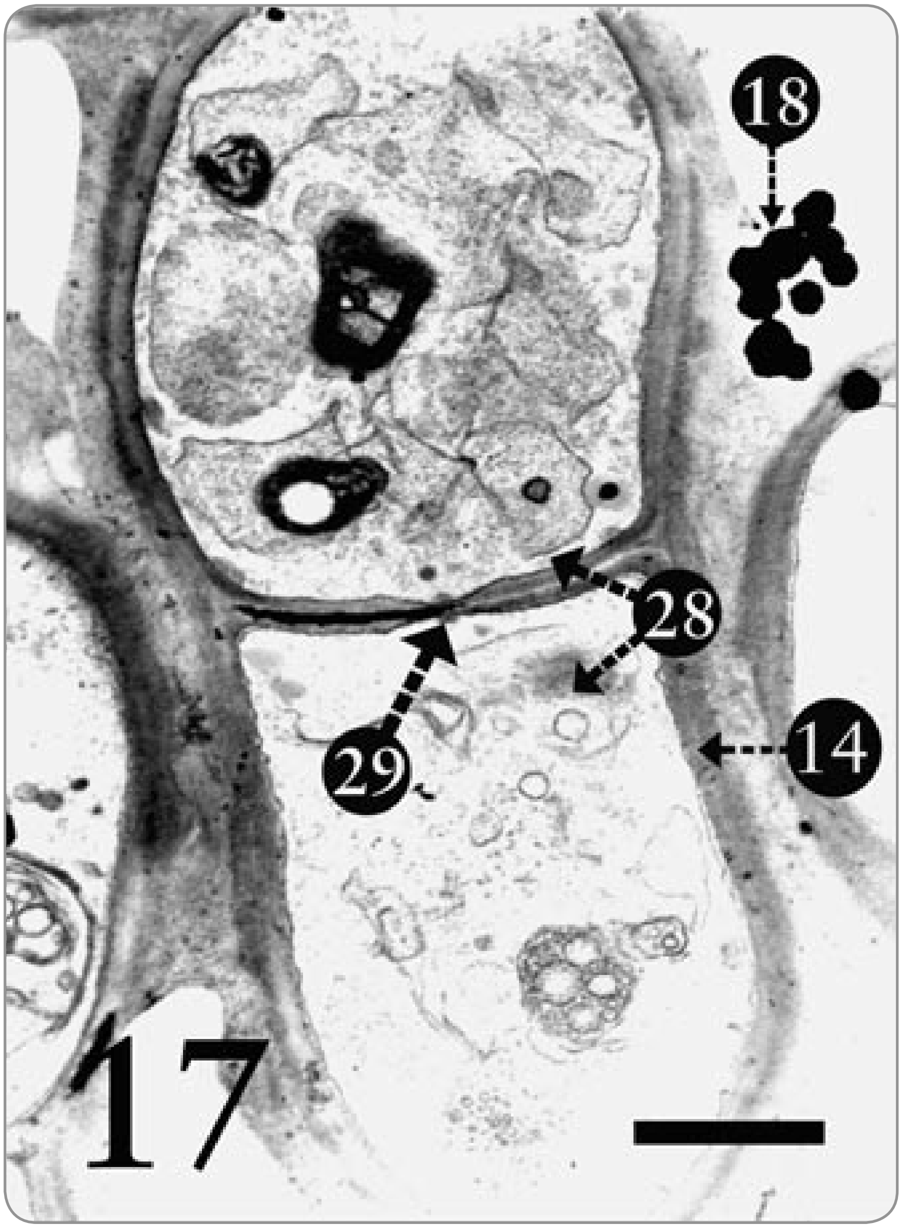
Figures 15 and 16 are highly magnified micrographs of hyphae in the circular developing ascocarp that had been ascending (item "5" in Figure 1 in Armitage and Howe, 2007). Our micrographs in Figures 15 and 16 closely resemble hyphae in sketches of developing asci drawn by Hale (1967, p. 35, Figures d–i). The hyphae that actually produce the ascus sacs "remain non-septate and are much richer in protoplasm than the others [hyphae]" (Fink, 1935, p. 17).

For a discussion of the spherical nature and upward movement of the developing ascocarps, see Armitage and Howe (2006, pp. 262–263). The possible roles of mycobiont ascocarps and their ascospores also were discussed in Howe and Armitage (2002). Furthermore, we have discussed the apparent non-utility of ascocarps and ascospores of mycobionts, whereby lichens generally employ alternative asexual means to reproduce the whole thallus (Armitage and Howe, 2006).

Mycobiont Ascocarps Are Not Useless Remnants of Evolution

In portions of our previous papers, we discussed the concerns of Ahmadjian regarding the fact that ascospores seem to play little or no role in the reproduction of most lichens. One might assume at first thought that ascospores

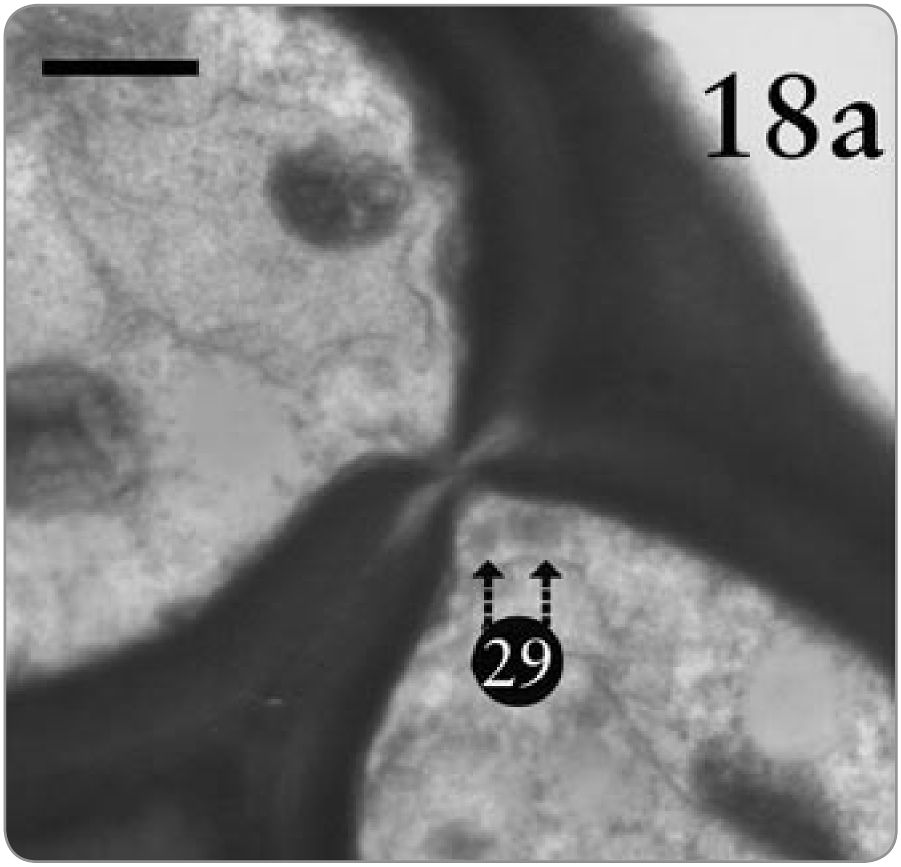
Figure 17. Mycobiont cells of the lichen *Caloplaca sp.*: magnification 12,000X; the scale bar is 30 micrometers. A perforated septum (28) separates the upper and lower cells (28). The unnumbered hole between them can become clogged by a pluglike structure known as a Woronin body (29). Woronin bodies can plug damaged hyphae, serving to prevent further loss of cytoplasm from the cells. The cytoplasm of the upper cell here is fragmented (as in certain cells of Figure 17), perhaps indicating the synthesis of spores, if this is in fact a developing ascus in an apothecium.



are routinely able in nature to capture free-living phycobionts, thereby reestablishing the lichens *de novo.* As we have discussed in our previous papers, however, Ahmadjian (2002, pp. 2–3) has asserted that such a resynthesis of lichens rarely if ever occurs, and is somewhat of a lingering “myth.”

We shall discuss evidence in conflict with Ahmadjian’s idea, but even if he is correct in stating that lichen resynthesis does not occur in nature, ascocarps and their ascospores should not be considered “vestigial.” The spores have been shown to germinate, forming hyphae in culture experiments. Having endowed lichens with various means of asexual reproduction, the Creator perhaps refrained from canceling the fungus subroutines for producing ascospores and other sexual cells. Germinating ascospores and free-living *Trebouxia* have in fact been reported to resynthesize lichens in nature. Thus, the sexual process still may be involved in the reproduction of lichens.

Ott (1987) showed that ascospores are not vestigial in the lichen *Xanthoria parietina. Pseudotrebouxia*, the phycobiont of this lichen, sometimes (but rarely) is able to exist in a free-living condition. Sexual reproduction can and does take place in the mycobiont because ascospores grow and produce new hyphae in nature. Ott reported that these hyphae made contact with various



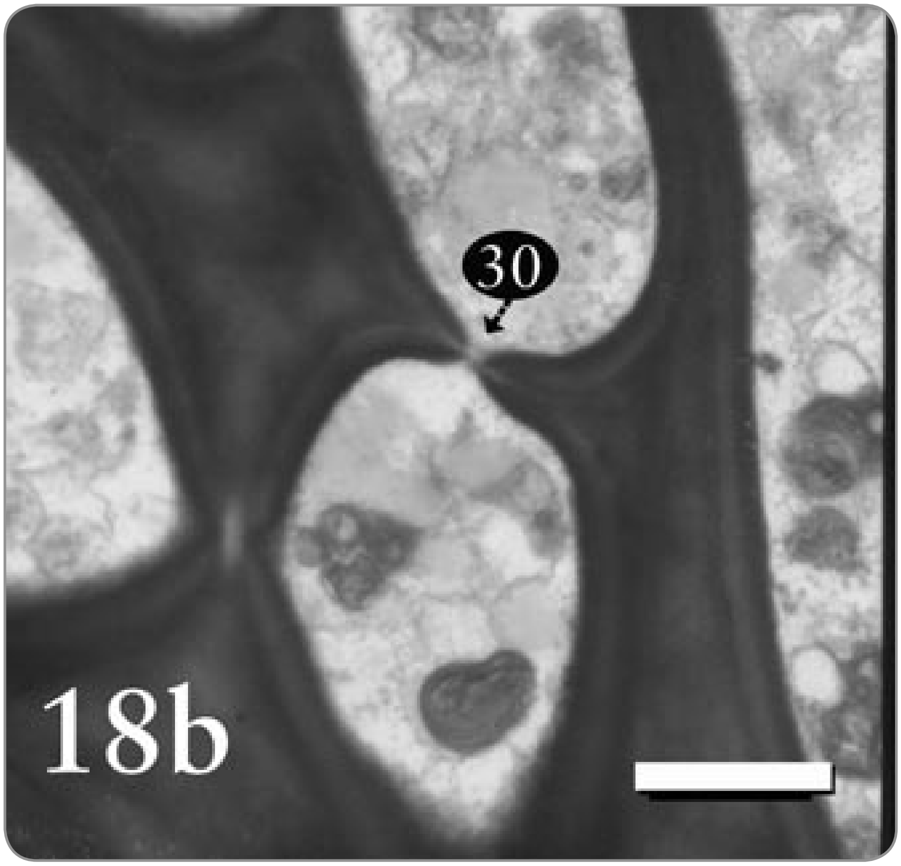


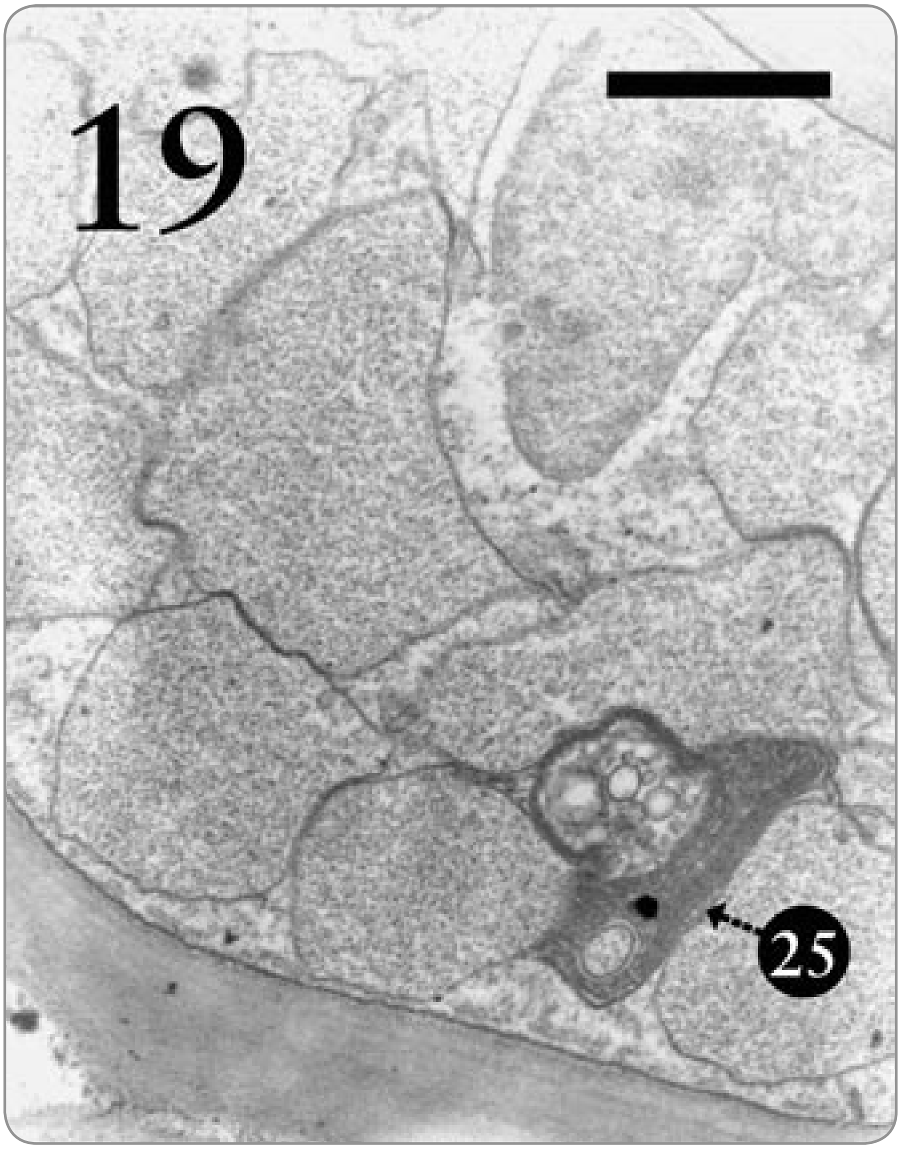
Figure 18. (A) This TEM of two adjacent mycobiont cells from *Candelariella sp.* shows the septum pierced by a pore, which connects them. In the lower cell, two Woronin bodies (29) are faintly visible, hovering near the pore. (B) Here is another view of the hole or pore (30) in the septum between two adjacent fungal cells in *Candelariella*. The cells make direct contact through this pore. The magnification of 18A is 20,000X (scale bar 8 micrometers) and 18B is 10,000X (scale bar 20 micrometers).

algae and, by a rather involved stepwise interplay, finally produced a new X. *parietina* lichen thallus. Other studies show that even the lichens having *Trebouxia* as a phycobiont can be resynthesized in nature.

Myelin-like Structures

Some objects possessing alternating layers of electron dense and electron non-dense material are labeled "25" on Figures 16 and 19, and on Figure 11 of Armitage and Howe (2007). Although usually small, some of these objects like the one in Figure 19 are much larger. Their layered appearance resembles nerve cells and thus we are adopting the term "myelin-like" to describe them, an adjective employed by other workers for similar structures found in both mycobionts and phycobionts (Jacobs and Ahmadjian, 1971; Peveling, 1973, p. 158). Current literature does not appear to provide possible functions of myelin-like bodies. Holopainen and Karenlampi (1984) reported an increase in the number of myelin-like bodies in lichens as one of the injuries resulting from sulfur dioxide fumigation.

Figure 19. Part of a fungus cell from the lichen *Caloplaca sp.* at a magnification of 14,000X with a scale bar of 9 micrometers. The cytoplasm is divided into many fragments, possibly indicating that spores are being formed. The dark object at the lower right (25) has alternating dark and light layers like the myelin-like bodies, shown and discussed in Figures 11 and 16.



Septal Pores and Woronin Bodies Exist in the Fungi of Lichens

Two neighboring mycobiont cells (number 28, Figure 17) have a septal pore in the cell wall between them (see Figures 17, 18a, 18b, number 30 for septal pore and consult Peveling, 1976, p. 24). Septal pores range in diameter from 0.05 to 0.5 micrometers (Moore-Landecker, 1990, p. 17). They show that the protoplasts on each side of the septum "are connected by living strands that pass through the pore or pores and connect adjacent cells" (Alexopolous and Mims, 1979, p. 9).

Pluglike entities called Woronin bodies (Peveling, 1973, p. 161) are visible in our Figures 17 and 18 where they are numbered "29." They have been found to be present in over 50 species of filamentous fungi (Jedd and Chua, 2000). Hawksworth et al. (1995, p. 489) defined Woronin bodies as "rounded or elongated oval highly refractive bodies in the cells of certain discomycetes [an alternate name for ascomycetes], particularly in association with septa," a definition similar to the one published by Beckett et al. (1974, p. 87). Peveling described them as "bodies of an unknown nature associated with pores and plugs" (1976, p. 24). They are granular objects, surrounded by a double "unit membrane" (Moore-Landecker, 1990, p., 17). Woronin bodies are spherical, hexagonal, or rectangular in shape, membrane bound structures with a crystalline protein matrix (Paleos, web site 2006). They originate from what are called "microbodies" (Alexopoulos and Mims, 1979, p. 237).

Neither their exact composition, nor their precise functions have yet been determined (Jedd and Chua, 2000). The gene called HEX l triggers a mechanism that assembles Woronin bodies. The loss of the HEX l gene in the fungus *Neurospora* leads to a cytoplasmic bleeding condition (Jedd and Chua, 2000). Jedd and Chua (2000) see them as peroxisomes, which reseal the plasmalemma. We suggest that such organic engineering strongly validates design in the origin of fungi and lichens.

Woronin bodies are thought to block the septal pore, thereby preventing loss of cytoplasm when the hyphal strand is damaged (Deacon, 1990). This would make them a first line of defense against mechanical injury, as another worker indicated:

> While the hypha is healthy, the Woronin bodies remain in their usual position in the cytoplasm adjacent to the pore…but when a hyphal cell ages or becomes damaged, the woronin bodies move into the pore and become a plug. This plug effectively separates the cytoplasm of the aged or damaged cell from the cytoplasm of the cells that are still healthy…Experiments have shown that if hyphae are cut, plugging of the septum would occur in four seconds. (Moore-Landecker, 1990, pp. 17–18.)

The Palaeos web site (2006) discussed Woronin bodies and described their plugging function as follows:

> A unique character of the Ascomycota (but not present in all ascomycetes) is the presence of Woronin bodies on each side of the septa separating hyphal segments, which control these septal pores. If an adjoining hypha is ruptured, the Woronin bodies block the pore to prevent the loss of cytoplasm into the ruptured compartment" (Palaeos, 2006).

"When a cell is injured," wrote Beckett et al. (1974, p. 87), "the Woronin bodies appear to coalesce and plug the pore." Peveling (1976, p. 24) listed the storage of metabolic substances and their transference from cell to cell through this pore as other possible functions of Woronin bodies.

There is a high level of functionality present in very small subcellular organelles such as mitochondria, pyrenoglobuli, and Woronin bodies. This shows that the Creator employs microscopic mechanisms to perform great objectives, as repeatedly seen in nature (Armitage, 2007). The Bible record also shows that God accomplished unusual results by utilizing insignificant means. Christ fed thousands of people, for example, by starting with nothing more than a small boy's lunch.

Mycobiont Haustoria Secure Foods from the Phycobiont Cells

Within the algal zone, the mycobiont produces penetration tubes called haustoria that press directly into the phycobiont cells (see Figure 20). These provide effective surfaces for the transport of photosynthate to the mycobiont, which is dependent on the alga for its food supply. In our earlier photographs, using very thin micro-sections, we found no haustoria. In later micrographs involving thicker sections, however, haustoria were visible (Figure 20; see also Figure 7 in Armitage and Howe, 2006).

Do New Lichens Arise in Nature Now from the Union of Free-living *Trebouxia* Cells and Germinating Fungus Sporelings?

There is a difference of opinion concerning whether or not the fungi and the *Trebouxia* phycobionts can combine successfully in nature to resynthesize a particular lichen. As early as 1976, it was realized that lichens containing blue green bacteria as their photobionts could go completely back to a free living state and then be resynthesized as *bona fide* lichens, even containing concentric bodies (Marton and Galun, 1976).

In 1987, Ott reported that some rare, free-living populations *Pseudotrebouxia*, an alga similar to *Trebouxia*, do exist, as indicated earlier. Populations of *Trebouxia* itself have been isolated from bark, soil, and plant material in nature (Tschermak-Woess, 1988, p. 81). Mukhtar et al. (1994) used morphological and immunological methods to show that "free-living *Trebouxia* cells [were] among the first settlers in an area that has been completely sterilized by a forest fire" (p. 247). Galun (1988b) reviewed experimental evidence supporting the idea that *Trebouxia* is able to unite with fungi outdoors, producing lichens.

Nonetheless, Ahmadjian (2002) maintained that *Trebouxia* lives only in lichens and that "free living *Trebouxia* do not exist" (Ahmadjian, 2001, p. 383). He considered the idea of lichens arising in nature from *Trebouxia* populations and fungus sporelings to be "a myth" (Ahmadjian, 2002, p. 1). He seriously pondered this supposed lack of free-living *Trebouxia* and expressed the puzzling fact that, "vast numbers of [mycobiont] spores are discharged from countless ascocarps produced by lichens" (Ahmadjian, 2002, p. 2). Thus, there is an unresolved difference of opinion between lichenologists over whether or not *Trebouxia* lives free and unites in nature with fungus sporelings to produce lichens. If some natural resynthesis of lichens containing *Trebouxia* does occur, possibly it is not prevalent or widespread. More research is needed on the question of whether or not free-living *Trebouxia* populations occur and whether or not those algae are regularly engaged by fungi to resynthesize lichens. There is another question, which we are not analyzing here, of whether or not phycobionts other than *Trebouxia* can maintain free-living populations and whether or not they resynthesize lichens with their fungi in nature.

Did the Origin of Lichens Occur by Macroevolution or by Rapid, Special Creation?

Macroevolutionists Have Assumed What Needs to Be Proved

Some macroevolutionists speculate that free-living *Trebouxia* or other algal cells somehow grew together with fungi to form the original lichens. They assert

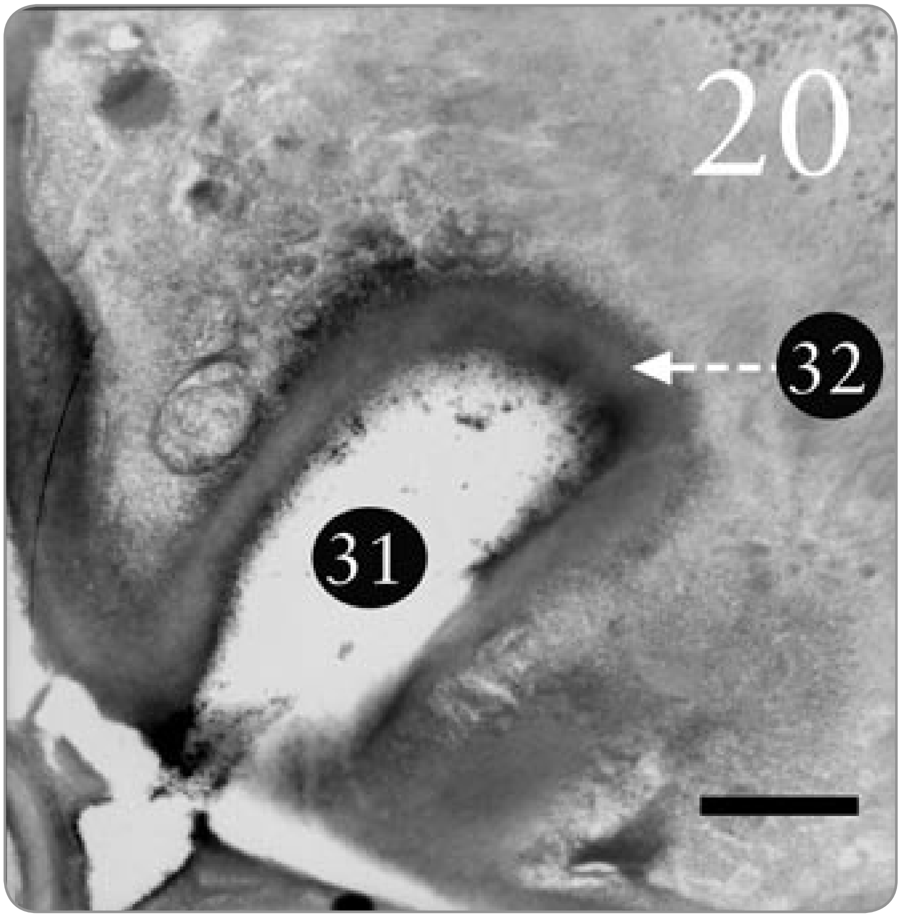


Figure 20. *Trebouxia* cell of the lichen *Acarospora sp.* with a bulgelike indentation (31). We think this indentation is a haustorium entering the mycobiont cell from a nearby phycobiont. Note the pyrenoglobuli above the large number "2" in the "20," proving that the cell above is an algal cell. The size bar is 3 micrometers. The cell wall (32) includes the wall of the fungus haustorium and the cell wall of the alga, closely pressed together. Haustoria afford a great increase in the area of contact between the fungus and the alga, allowing for a more rapid transfer of photosynthate.

that it all started long ago as a result of potential mycobiont fungi searching for food among nearby photobiont cells. Concerning the actual origin of lichens, however, the creationist Cairney (1975) wrote that "no naturalistic means has been found for supposed evolutionary development of such an association" (p. 211). He also asserted that "there is scanty evidence of any evolutionary progression leading up to lichen associations" (Cairney, 1975, p. 212). Evidently, neo-Darwinian macroevolutionists have little or no evidence to show that lichens arose when ancient fungi searched for food among free-living algae.

Did Fungi Originate by Evolution?

Lichens are supposed to have been both "ancient" and "early," preparing the way for other forms of life on land. Such speculation is not borne out by genetics: "Interestingly, recent molecular studies provide no support for the idea that lichens living today are 'ancient' compared with other fungi" (Purvis, 2000, p. 47). He added that the very taxonomic order to which most of the lichen fungi belong, the Lecanorales, is a relatively "advanced group of ascomycetes," (Purvis, 2000, p. 47). After acknowledging this, Purvis (2000) then tried to deflect the obvious inference (that lichens are really quite "advanced" phylogenetically) with the following gratuitous remark: "This evidence does not mean that lichen-like associations were not among the first to conquer land" (p. 47). But if lichens were actually among the first plantlike creatures on land, as implied, those putative, primitive first lichens evidently were not the direct ancestors of today's lichens, because contemporary lichens are quite modern [advanced] in structure.

There is a striking resemblance between spores of living fungi and fossil fungi, the latter of which are thought by macroevolutionists to be millions of years old.

> Fossilized fungal spores in deposits up to 60 or so million years old can be found fairly readily. Many are highly distinctive and extremely similar to present day species…Such fossils give a strong impression that even the most distinctive fungal morphologies are maintained for long periods of time … The close similarity between the fossil specimen and existing genera again emphasizes the trend in fungal evolution to conserve form and morphology over very long periods of time (Moore, 1998, p. 16, 18).

Thus, little or no evolution of fungal spores has transpired over vast theoretical ages. Concerning the use of fossils in the study of fungus evolution, Moore (1998) further reflected that:

> Most aspects relating to the origin and subsequent evolution of fungi are impossible to establish from any fossil record, so ideas and concepts must be gleaned from other sources. (p. 9)

One of these "other sources" is evidently the comparative study of DNA sequences. What is being ignored in those phylogenetically based DNA comparisons, however, is that "similarity" does not necessarily indicate "kinship" or "common ancestry," but might instead demonstrate "design" and a "common Designer." Subsequently Moore (1998) mentioned a "general lack of convincing fossil records of fungal origin…" and added that, although there are similarities between red algae and fungi, "no evidence could be detected to support the idea that higher fungi and red algae might have shared a common origin" (p. 9).

Similarities between one particular lichenized fungus and a non-lichenized fungus may or may not indicate kinship between them (see Jacobs and Ahmadjian, 1969, p. 222). Similarities of this type could exist if the Creator had made two fungi quite similar: one to interact with an alga to make a lichen and the other to live without algae. Or, God may have created one form of fungus, directly modifying it thereafter to yield a lichenized and a non-lichenized version.

Questions Surround the Evolutionary Origin of the Alga *Trebouxia* and its Mycobionts

For many years, Ahmadjian has expressed the idea that free-living *Trebouxia* algae descended from the somewhat similar, multicellular alga *Pleurastrum terrestre*. He thought that somehow *P. terrestre* became unicellular and then "evolved as a result of association with fungi" (Ahmadjain, 1967, p. 38; see also Ah-madjian, 1993, p. 38). Such an ancestry for *Trebouxia* is obviously speculative. Ahmadjian (1967) remarked that, "lichen fungi must have originated from free-living forms, but there is little evidence to support this view" (p. 33). Moore (1998) likewise acknowledged that the fossils supply little or no evidence for establishing the evolutionary origin of lichen fungi.

The Lichen Thallus—an Evolutionary Puzzle

Jahns (1988) embraced the origin of the lichen thallus by evolution, but emphasized some of the problems involved. Non-lichenized fungi do not have any thallus, whereas lichenized individuals do. "Several theories try to explain the origin of the lichen thallus. An acceptable explanation is difficult to find" (p. 97). While the lichenized fungi have a complex vegetative thallus, the vegetative body of non-lichenized fungi is merely a "loose hyphal network" (Jahns, 1988, p. 97). Since lichens are deemed by evolutionists to be polyphyletic (to have formed repeatedly from unrelated sources), it is necessary for evolutionists to also espouse the very unlikely proposition that the complex thallus of lichens evolved many times independently in unrelated fungal taxa.

More Problems for Evolution

Cairney (1975, p. 212) observed that if lichens did arise in nature by the evolutionary union of fungus and alga, the germinating fungal spores would have needed to find their critical algal partners immediately, something that would not have been likely unless free living *Trebouxia* colonies were widely distributed back then. But if independent *Trebouxia* populations once were quite successful in nature, why would they have begun to cohabit with fungi? Also, why would such free-living *Trebouxia* populations have become somewhat scarce thereafter? If it were once possible for *Trebouxia* to unite readily with fungi, why does this not happen regularly now in nature, when both partners are highly "coadapted" to live together?

Ahmadjian and other workers have found that *Trebouxia* and certain mycobionts can be cultured independently in the lab where the alga and its fungus then can be brought together to yield lichens. But all such laboratory syntheses of lichens have "required a carefully controlled program of environmental alterations" (Cairney, 1975, p. 212). Cairney also stated that, "where lichenization has actually occurred in the laboratory, conditions have been carefully and intelligently contrived to bring about the association." He concluded that, "the creationist view of the lichen association is the one which best fits lichen synthesis data" (p. 212).

One of our reviewers suggested that evolutionists probably have developed a logically consistent hypothesis of the gradual development of symbiosis in the literature and that we would do well to review it here. However, we are unable to locate such a coherent hypothesis. We invite letters to the editor if such an evolutionary attempt has been produced; we would indeed like to review and evaluate it. For the most part, lichenologists bring up evolution as if it were an accepted fact, spending little if any time attempting to sketch credible scenarios based on experimental data. In a previous paper (Armitage and Howe, 2004), we have listed quotations from evolutionary lichenologists demonstrating that they have assumed what needs to be proved and have communicated presuppositional beliefs rather than origins scenarios based on scientific data.

A Creation Origins Model for Lichens

Although lichens are currently not included in the plant kingdom, their phycobionts and even their mycobionts resemble plants in many ways. We will thus assume that algae and fungi were created on the third day of creation, when it is reported that God made other plants, including seed plants, by commanding the earth to bring forth green vegetation, "plants … and trees bearing fruit with seed in it, according to their kinds" (Gen. 1:12 NIV).

In opposition to this creation of all plant types on one day, evolutionists believe that simple plants emerged first and evolved gradually to form the more complex plants across vast theoretical ages. The evolutionary view obviously does not fit with the biblical narrative, despite arguments from "theistic evolutionists." The Bible says nothing of "common ancestry" or evolutionary descent in the creation of plants. Nor does it imply the existence of vast ages, but assigns the origin of plants to one real creation "day."

The long ages of evolutionary progress cannot be confirmed by science either. Both the time and the need for plants to arise by macroevolution disappear if they were directly and recently created in one day. There is no conflict between this young earth creation model and experimental science.

We do not profess to understand the steps or sequences used by the Creator in His work. Like macroevolution, special creation entails processes that are, as yet, undiscovered. Perhaps God made the free-living algae and the non-lichenized fungi first, and then later coupled algae with various fungi to yield the ancestral lichen "kinds." As one of our critical readers suggested, God may have "endowed all higher fungi with the ability to form a lichen thallus if given the right trigger." More work is needed on what these triggering phenomena might involve.

Some time after Creation week, God's curse upon human disobedience affected the ground bringing forth thorns and thistles (Gen. 3:18). The text does not say that thorns and thistles were created after this curse, but that the ground would then favor their growth. Nevertheless, it is possible that the Creator made certain changes in plant kinds at the time of Genesis 3:18, initiating thorns and thistles. If there had been preexisting unexpressed genes for thorns and thistles, for example, God might have caused those genes to be expressed at that time. While not specifically stated in the Bible, perhaps lichens were generated from preexisting, non-lichenized fungi and free-living algae in the context of Genesis 3:18.

Before the curse of Genesis 3:18, perhaps all fungi were either symbiotic (such as mycobionts living inside lichens) or otherwise non-pathogenic. Perhaps pathogenic fungi, disease causing bacteria, and viruses were each formed by God from non-pathogenic ancestors, as part of the curse. Perhaps mutations resulting from the fall were involved. Accordingly, a non-symbiotic fungus that closely resembles a certain lichen mycobiont could be the descendant of that mycobiont instead of being its ancestor.

After the global flood (described in Genesis chapters 6 through 9), God may have enacted changes upon the created "kinds." At this time, plants and animals were becoming reestablished in many novel, post-Flood habitats. While the Bible says that the heavens and the earth "and all their host" were finished when the Creation week was over (Gen. 2:1), the Creator might still have made minor adjustments thereafter. He may have synthesized some lichens rapidly in that early post flood period by genetically altering certain fungi, enabling them to join with various algae.

Matters like these, and other related questions, such as how God might have preserved lichens during the Flood, deserve further attention by creation-minded scientists. We think that the creation view, with certain unknown and maybe some unknowable features, still finds far greater fit with the scientific origins data than does the neo-Darwinian macroevolution. The detail seen in lichen ultrastructure is fully accountable in a creation origins model.

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Although disagreeing with the philosophical presuppositions of many lichenologists, we are nonetheless grateful for their detailed studies of God's little lichens.

With deep and final appreciation, we respectfully acknowledge the exceedingly skillful work of the Creator, as reflected repeatedly in the ultrastructure of lichen cells.

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Lava Extrusion and the Age of Iceland

Peter Klevberg*

Abstract

The Mid-Atlantic Ridge is both a salient feature in the earth's crust and a centerpiece for plate tectonics. It emerges from the sea in Iceland, a land famous for its active volcanism. Field and published data are integrated to better quantify lava extrusion rates and apply these results to natural history scenarios, including the uniformitarian and diluvial geologic paradigms. Also relevant are tectonic models, particularly the standard plate-tectonics model and its diluvial counterpart, catastrophic plate tectonics. Iceland provides a unique opportunity to compare diluvial predictions with those of common uniformitarian origin theories. Both field and published data are better explained by the diluvial geologic paradigm than by traditional theories. Both plate-tectonics models can be applied to the Mid-Atlantic Ridge in general and to Iceland in particular; however, a number of problems remain, and plate tectonics cannot change the chronological implications of the structure of the Icelandic lava pile.

Iceland as a Guide to Global Geology

There is probably no country in the world that has a higher percentage of geologists among its tourists than Iceland, and this in spite of its relative isolation in the North Atlantic Ocean touching the Arctic Circle. There are good reasons for this. Iceland is the only place where the Mid-Atlantic Ridge emerges from the sea, and it is one of the most volcanically active places on the planet. This high degree of activity is widely attributed to the Mid-Atlantic Ridge, generally believed to be the divergent margin between the North American and Eurasian tectonic plates, and a mantle hot spot (Saunders et al., 1997). Tuyas—volcanic table mountains attributed to subglacial volcanism—are unique to Iceland (Sigurjónsson and Tulinius, 2001). Vatnajökull, the world's third largest ice cap, and a score of prominent glaciers provide a means of studying glacial erosion. Catastrophic releases of meltwater from subglacial eruptions provide invaluable insight into sedimentation processes. But Iceland's main claim to geologic fame results from the virtually universal acceptance of the plate-tectonics paradigm and the special role that Iceland has in plate-tectonic theory (Figure 1).

Iceland is unique not only for the sheer magnitude of volcanic activity, but also for a strong tradition of accurate and detailed history that has characterized the Icelandic people since the time of settlement (*Landnám*) in A.D. 874. In 1783–1784, the priest Jón Steingrímsson recorded in detail his experience of the eruption that occurred along the Laki fissure (Lakagígar), the largest outpouring of lava for which reliable extrusion rate estimates are available (Fell, 1999; Self et al., 1997). The Eldgjá eruption in A.D. 940 (Figure 2) was comparable to Lakagígar, though apparently even larger (Bardintzeff and McBirney, 2000).

Much of Iceland consists of flood basalts, vast strata of conformable lava flows. Although immense in area and

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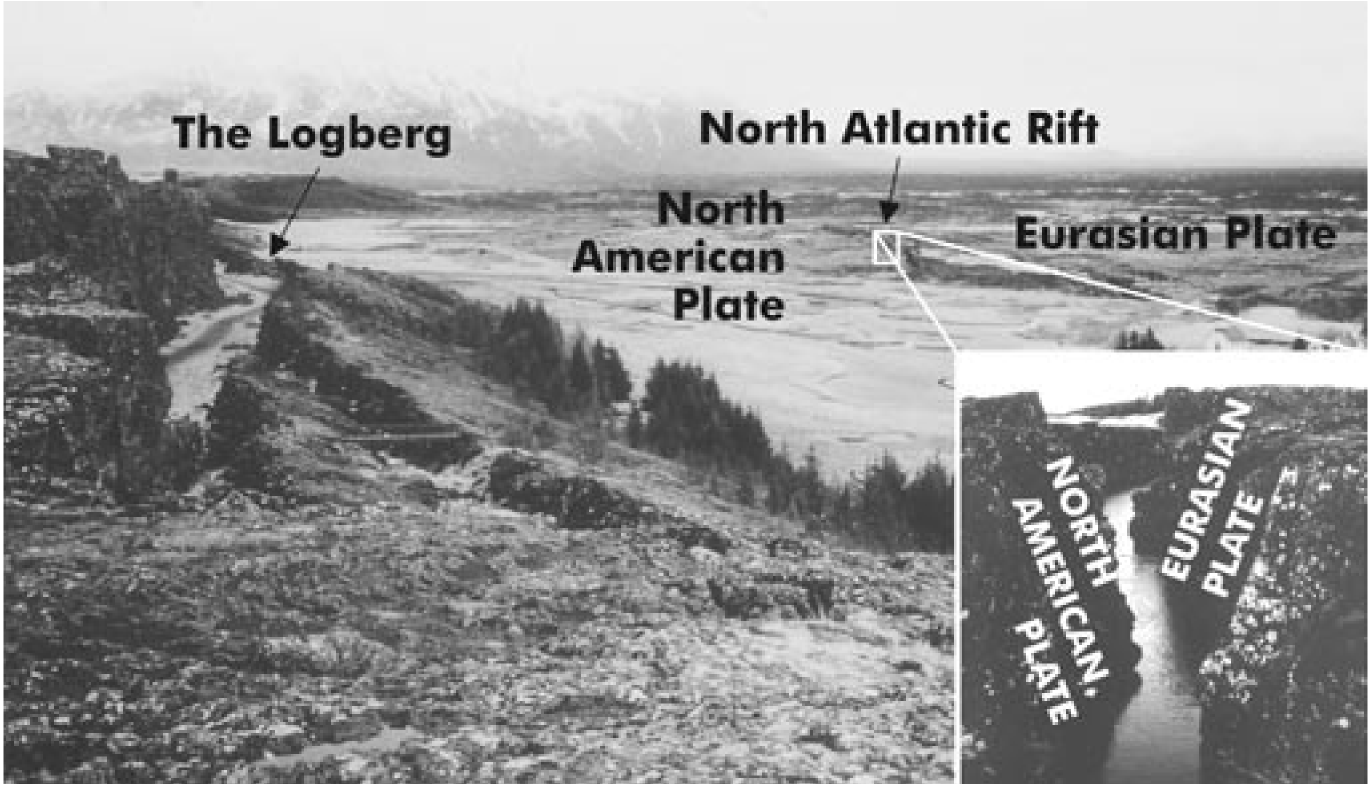


Figure 1. "The rift" at Þingvellir with the North American and Eurasian plates claimed to show plate tectonics in action. In reality, the situation is more complex. Þingvellir forms the north end of an en echelon fault zone at the west end of the southern offset in the North Atlantic Ridge (see Figures 3, 4, 5, and 6).

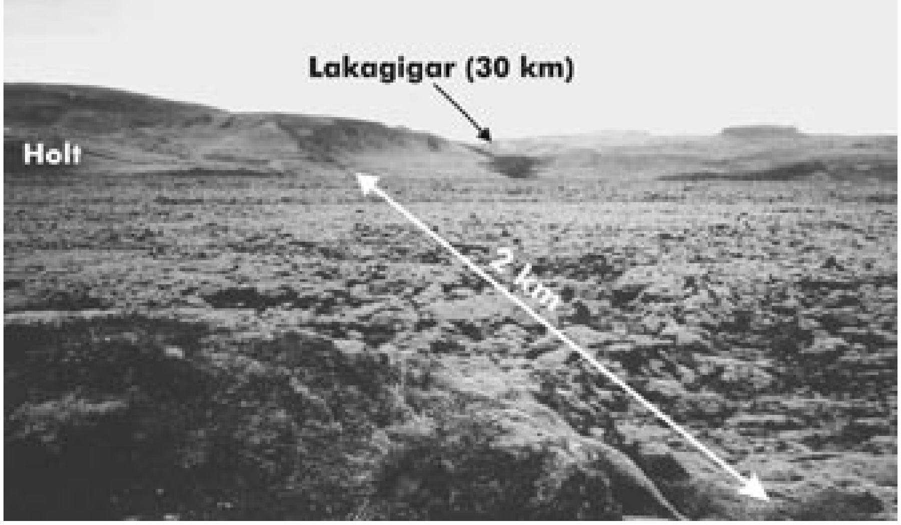


Figure 2. Eldhraun, a huge lava flow that issued from Eldgjá in 934 A.D. It was comparable to the famous Lakagígar eruption that occurred nearby in 1783. In the 1,068 years between Eldgjá and the time of the photograph (2002), lichens and mosses colonized Eldhraun, and soil formation is underway. Photograph taken north toward farm of Holt; at this location, Eldhraun is 16 km wide. Total volume of Eldhraun is estimated at 15 km^3 (closer to 20 km^3 according to some); Lakigígar was 12 km^3.

volume, continental flood basalts are uncommon. They are characteristic of large igneous provinces (Table I) and have not been observed in recorded history. Many geologists speculate that flood basalts originate when a rift opens or a "hot spot" begins to burn through a drifting tectonic plate (White and McKenzie, 1989; Hooper, 2000). After the initial release of pressure, extrusion rates fall. The origin of Iceland is thought to be connected to the creation of the North Atlantic Igneous Province (or North Atlantic Volcanic Province) approximately 62 million years ago (Ma) (Hooper, 2000), at the opening of the Atlantic Ocean upon the breakup of Pangea. The North Atlantic Igneous Province (NAIP) stretches from Greenland to Scotland and includes the island group of Færöyane (Faeroe Islands) and a large swath of sea floor; much of the province consists of flood basalts (Figure 3).

Table I. Dimensions of Several Large Igneous Provinces.

Large Igneous Province	Estimated Initial Area (km^2)	Approximate Present Volume (km^3)	Estimated Initial Volume (km^3)
Ontong Java Plateau[1,2]	$1.5 \cdot 10^6$	$1.5 \cdot 10^6$	$>5.7 \cdot 10^7$
Kerguelen Plateau[1]	?	?	10^7
North Atlantic Igneous Province[1,2]	$1.3\text{-}2 \cdot 10^6$	$6.6 \cdot 10^6$	$6.6 \cdot 10^6$
Keweenawan[1]	?	$1.5 \cdot 10^6$	$>2.0 \cdot 10^6$
Ethiopia-Afar-Yemen[1]	$6 \cdot 10^5$	$3.5 \cdot 10^5$	?
Siberian Traps[1,2]	$2.5\text{-}3.4 \cdot 10^5$	$3.4 \cdot 10^5$	$>2 \cdot 10^6$
Deccan Traps[1,2]	$5 \cdot 10^5$	$5.2 \cdot 10^5$	$1\text{-}2 \cdot 10^6$
Karoo[1,2]	$2\text{-}3 \cdot 10^6$	?	$1\text{-}2 \cdot 10^6$
Parana[1,2]	$1.2\text{-}2 \cdot 10^6$	$8 \cdot 10^5$	$1.5 \cdot 10^6$
Columbia River Basalt Group[1,2]	$1.6 \cdot 10^5$	$1.8 \cdot 10^5$	$1.8 \cdot 10^5$

Data from [1]Hooper, 2000, p. 349; [2]Bardintzeff and McBirney, 2000, p. 67.

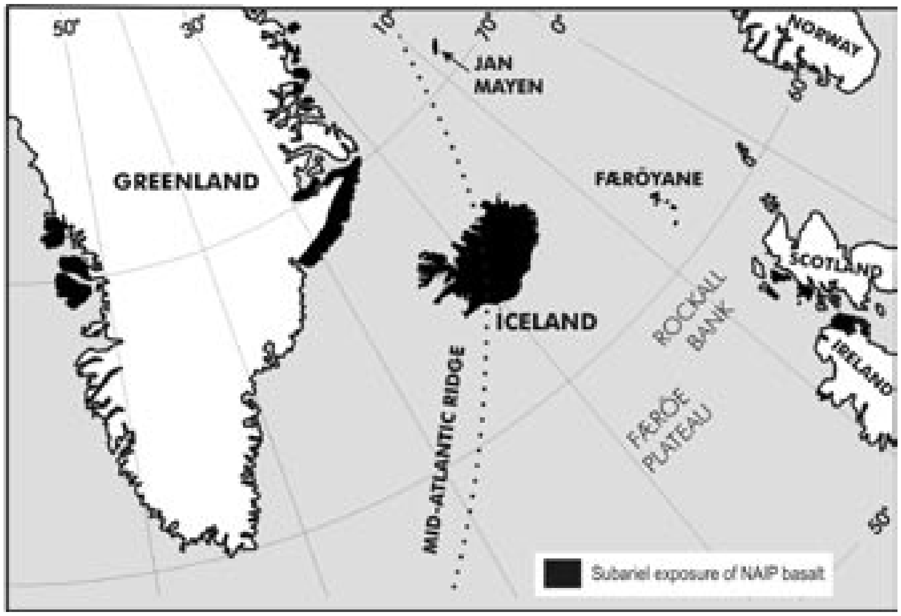


Figure 3. Map of the North Atlantic Igneous Province. Modified from Comité National Français de Géologie (1980) and Mahoney and Coffin (1997).

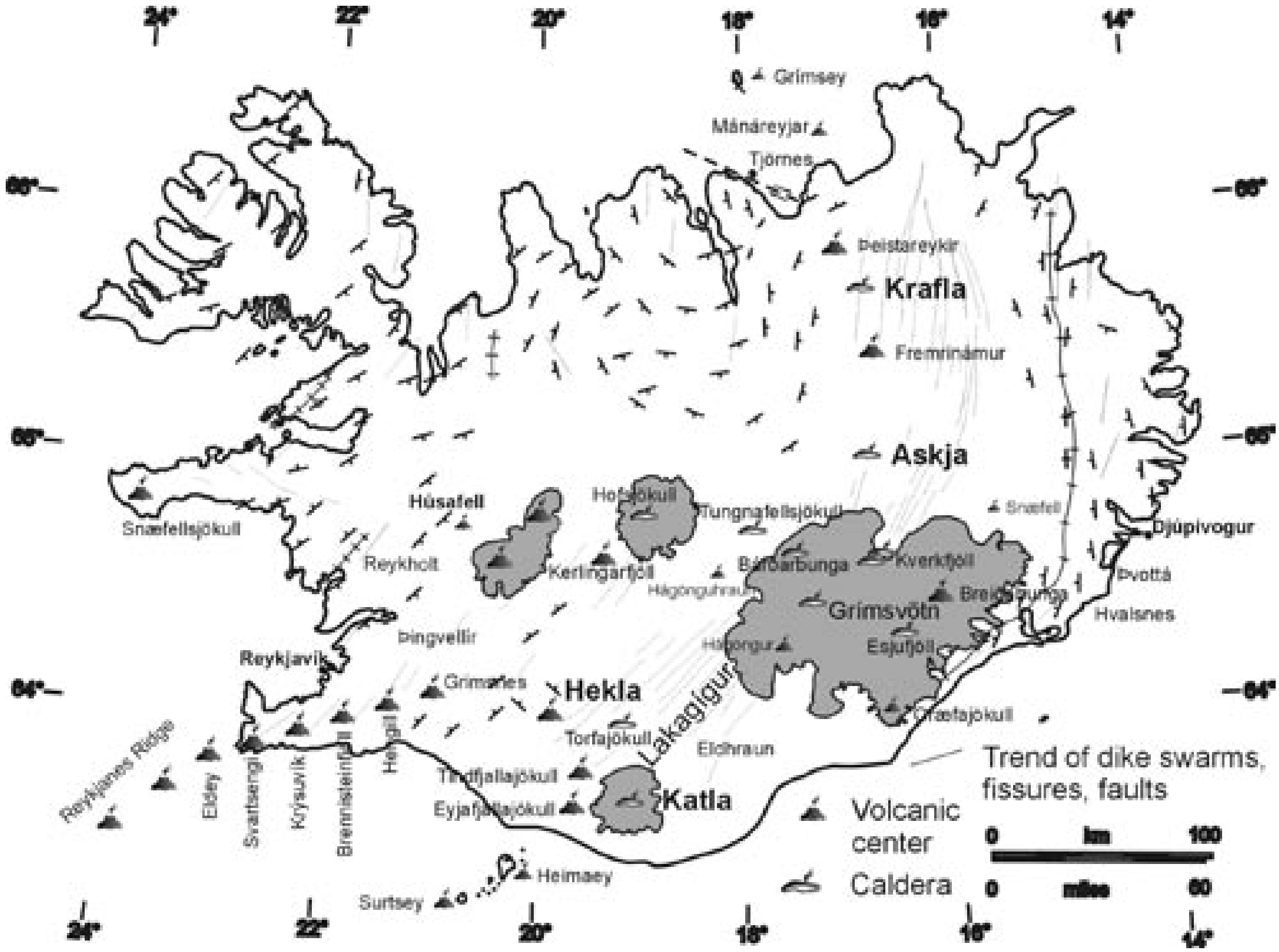
This paper integrates limited fieldwork with published data relative to lava extrusion rates at the Mid-Atlantic Ridge and Iceland. In an effort to gauge the reliability of published information and to accurately assess the geologic situation in Iceland, I spent one week conducting a field reconnaissance of southern Iceland in April of 2002 and collected rock samples for subsequent study. Nongeologists may benefit from Appendix A —a "volcanology primer"—and the glossary of fundamental geologic terms included in the text.

Field Observations in Iceland

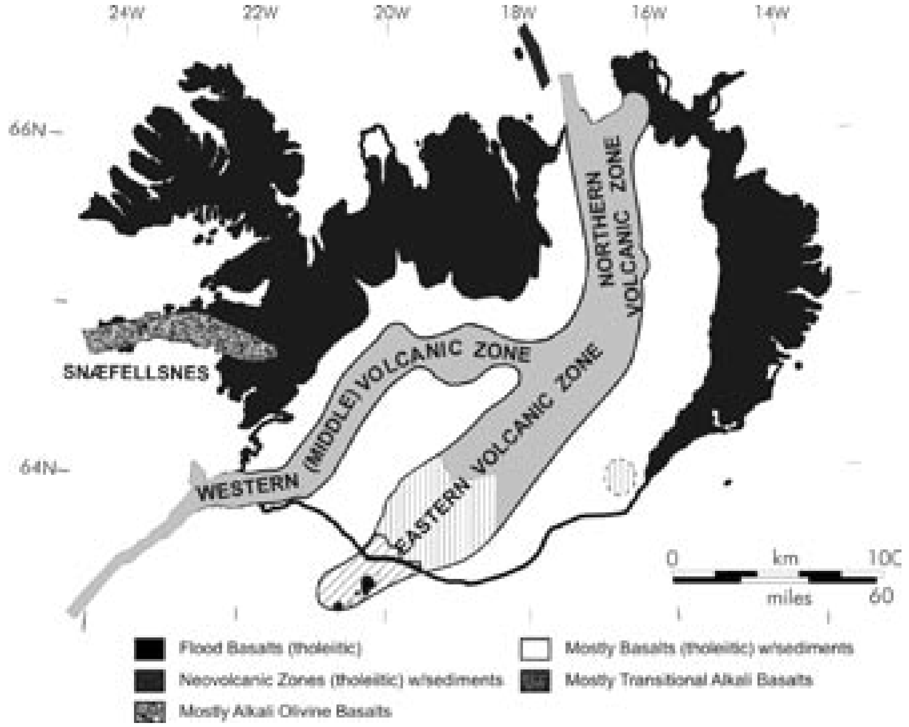
My reconnaissance followed the southern coastal highway from Reykjavik to Djupavógur as well as north of Reykjavik to Reykholt (Figure 4). Sites investigated included Þingvellir, Hekla, Eldhraun, Hvalsnes, Þvottá, and Tunga near Húsafell. (Lakagígar, Askja, and Krafla, though immensely important historically, were not accessible due to typical April weather.) Fieldwork followed a day at the University of Iceland viewing geologic maps and gathering other information (Guðmundsson et al., 1992; Jóhannesson and Sæmundsson, 1998; McClelland et al., 1989; Sæmundsson and Noll, 1974; Uppdráttur Íslands, 1989). Figures 4 and 5 are based on this limited fieldwork and considerable published information.

In general, Iceland consists of vast plateaus and ridges of flood basalts in the eastern and western portions of the country, with a split and curved zone of modern volcanism divided into the West, East, Middle, and North Volcanic Zones (Foulger et al., 2001). The Mid-Atlantic Ridge emerges from the ocean in the form of the Reykjanes Peninsula (Figure 6) and, after following the circuitous path of the volcanic zones, is offset from its continuation north of Iceland, the Kolbeinsey Ridge, by the Tjörnes Fracture Zone. Historic flows are most concentrated along these volcanic zones. Flows and plutons interpreted as intermediate in age by geologists are largely found flanking the volcanic zones.

Flood basalts are commonly highly regular, conformable, tabular flows. In the west, they dip slightly (< 10°) to the southeast (Figures 4 and 7). In the east,



above: Figure 4. Simplified tectonic map of Iceland modified from Comité National Français de Géologie (1980); Einarsson and Björnsson (1980), Fridleifsson (1980), Jakobsson (1980), Jóhannesson and Sæmundsson (1998), Kristjansson (1980), Þorarinsson (1980), Þorarinsson and Sæmundsson (1980).


24W
22W
20W
18W
16W
14W
66N
64N
SNÆFELLSNES
WESTERN (MIDDLE) VOLCANIC ZONE
EASTERN VOLCANIC ZONE
NORTHERN VOLCANIC ZONE
0 km 100
miles 60
Flood Basalts (tholeiitic)
Neovolcanic Zones (tholeiitic) w/sediments
Mostly Alkali Olivine Basalts
Mostly Basalts (tholeiitic) w/sediments
Mostly Transitional Alkali Basalts

left: Figure 5. Simplified geologic map of Iceland modified from Comité National Français de Géologie (1980) and Jóhannesson and Sæmundsson (1998).)

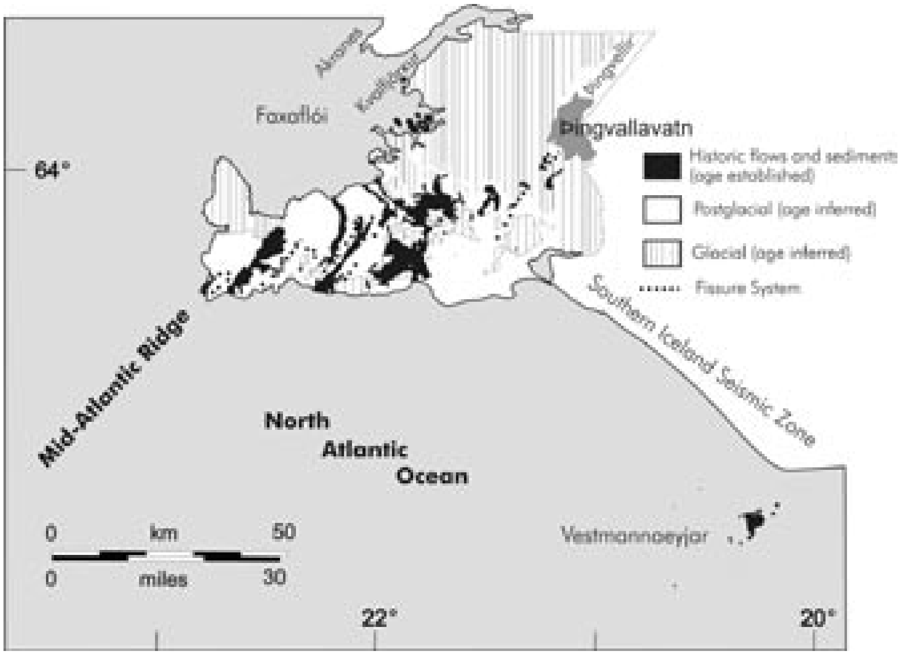


Figure 6. Map of Reykjanes Peninsula showing inferred ages of rock units. Modified from Jóhannesson and Sæmundsson (1998).

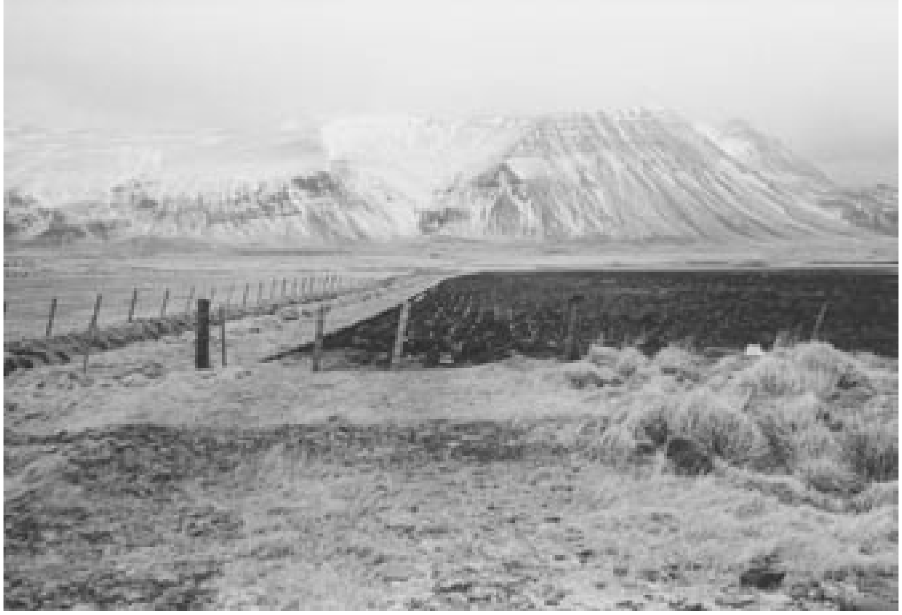


Figure 7. View south toward Skarðsheiði, showing continuity and attitude of conformable flood basalt flows in western Iceland.

they dip slightly (< 15°) to the northwest (Figures 4 and 8). Columnar jointing is common but not pervasive. Historic flows and rocks of the "intermediate" areas include both pahoehoe (Figure 9) and block flows (Figure 10); a'a is associated with some block flows (Figure 11). Contacts are sometimes planar but more often nonplanar, especially the smaller flows. In general, contacts throughout the southern part of the country are remarkably conformable (Figure 12), though volcanisedimentary and ignimbrite interbeds do occur, increasingly with proximity to neovolcanic zones. Weathering profiles at contacts between flows or evidence of paleosols were not observed. Only minor buried expressions of topography were seen, and only in the volcanic zones (Figures 13 and 14).

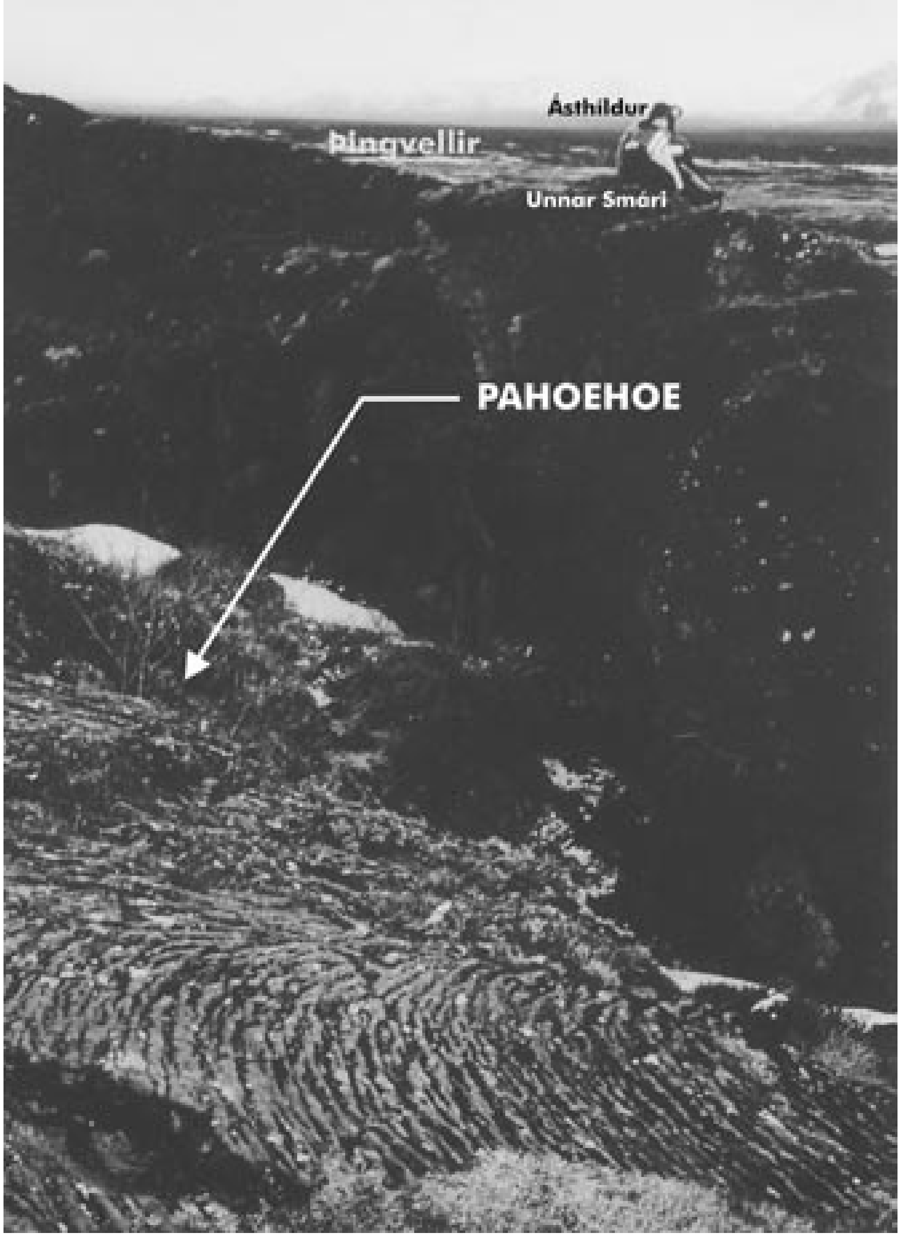
Soil erosion, especially due to wind, is extensive (Figure 15), yet soil formation appears to commence quickly as a result of rapid colonization of new basalt by mosses and lichens and entrapment of aeolian sediment (Figure 16).

By far the most common lithology I encountered in Iceland was basalt (tholeiitic), but intermediate and acid rocks were also observed near Hvalsnes, Þvottá, and Tunga (near Húsafell, Figure 4). Calc-alkaline rocks reportedly dominate Hekla, especially at the beginning of each eruption (Jakobsson, 1980; Stesky, 1997), but were not observed. Rhyolite is reportedly present northeast of Hekla (Sigurjónsson and Tilinius, 2001) and near Húsafell (Sæmundsson and Noll, 1974), but most of these areas were not accessible. Acid and intermediate rocks tend to occur in relatively small bodies closely associated with basalt in the rift zones and not the flood basalts (Saunders et al., 1997). Fine laminations and inclusions of glass were observed in dacite and associated rocks at Tunga (Figure 17).

Significance of Lithologic Data to Origin of Iceland

The most common lithology of Iceland is tholeiite, resembling mid-ocean ridge basalt (MORB), though lithologic variations are not uncommon (Figure 5), especially in the transitional and neovolcanic regions (Jakobsson, 1980). Basalt forms 90% of the lava pile (Sæmundson, 1980), resulting from Iceland's position

***left*: Figure 8. View west-southwest toward Búlandstindur from north side of Berufjörður near Berunes on the east coast of Iceland. Flood basalt flows dip 10 to 15° toward the west.**



***below left*: Figure 9. Pahoehoe flow at Þingvellir. Scale provided by 14-year-old Ásthildur and 8-year-old Unnar Smári.**

astride the Mid-Atlantic Ridge. The less common lithologies are less readily explained; they are not characteristic of the Mid-Atlantic Ridge. Subducted continental crust, the previously favored explanation (McBirney, 1993), cannot explain intermediate and acid rocks observed at Hekla and elsewhere. While appeals to recycling of crust are regularly invoked to explain strontium ratios, neodymium ratios, and other geochemical data (McBirney, 1993; Oskarsson et al., 1985), data are amenable to explanation by differentiation in magma chambers (Bardintzeff and McBirney, 2000; McBirney, 1993), interaction with water (Oskarsson et al., 1985), and mantle heterogeneity (Jakobsson, 1980; McBirney, 1993).

While efforts to find evidence of a fragment of continental crust beneath Iceland have been largely abandoned, neither diverse lithologies nor trace element studies have supported a simple MORB differentiation model: "Reconciling the chemical and isotopic evidence that indicates a lithospheric source with the large melt fractions that require a hot mantle plume source remains a fundamental problem in modeling the origin of flood basalt provinces" (Hooper, 2000, p. 351). Re-

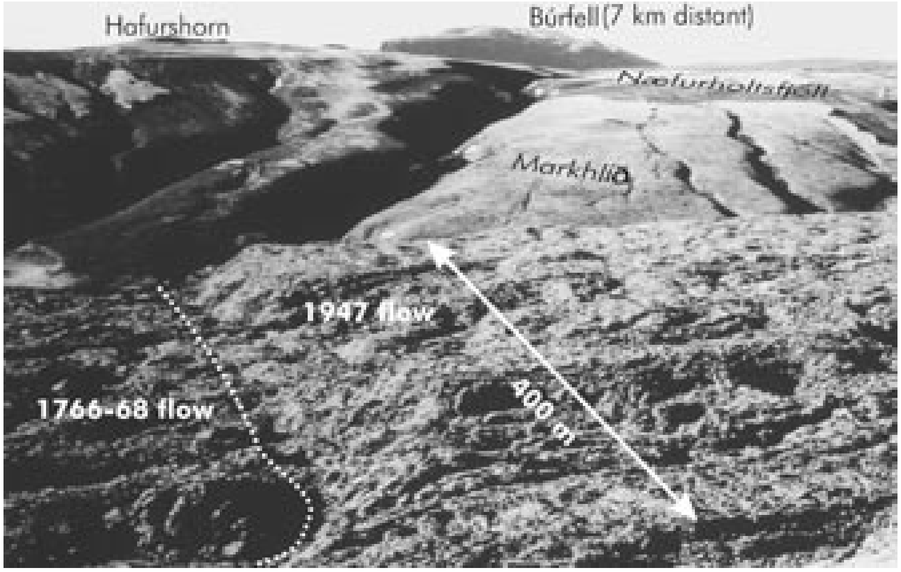


Figure 10. View northwest from Melfell over 1947 block flow from Hekla.

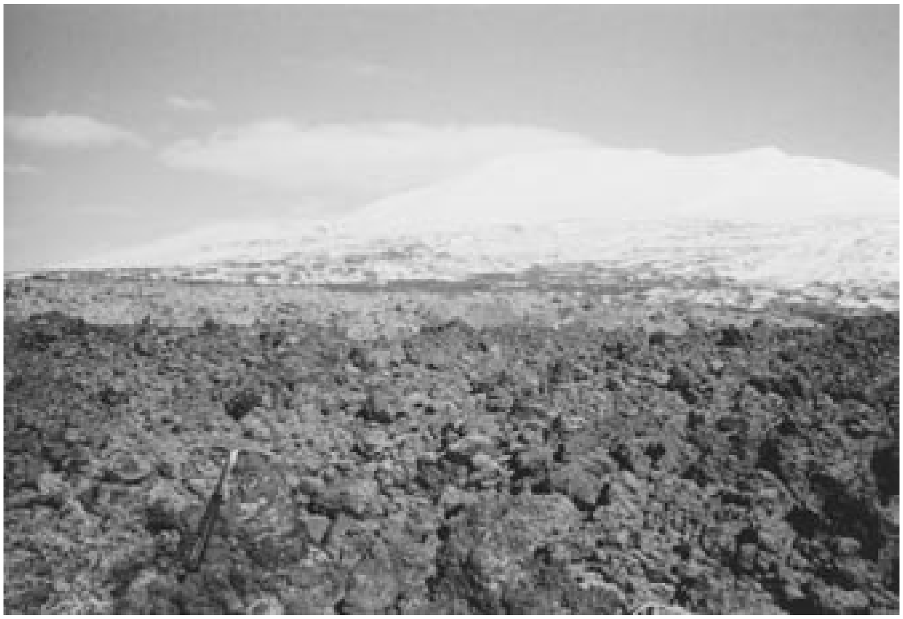


Figure 11. Lava blocks resembling a'a basalt on 1970 flow on west slope of Hekla. Most of exposed surface of lava blocks has already begun to be colonized by lichens.

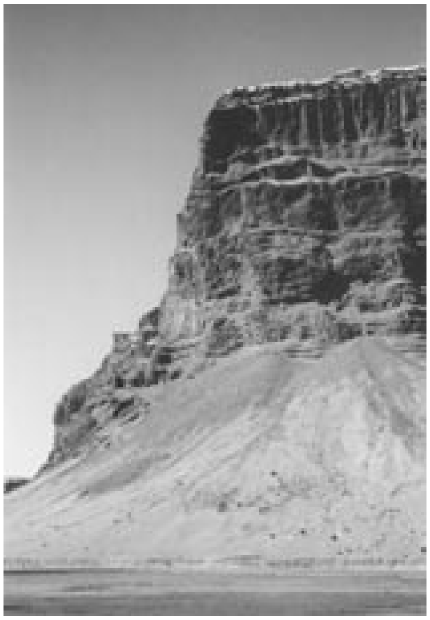


Figure 12. Vast conformable lava flows such as these exposed in the face of 767 m high Lomagnúpur are typical of Iceland. (Lomagnúpur is on the southern coast between the Eastern Volcanic Zone and Vatnajökull.)

cycling of oceanic crust and new ideas about mantle composition and structure are gaining favor among researchers (Anderson, 2001; 2002; Federova et al., 2005; Foulger and Anderson, 2005; Oskarsson et al., 1985). These studies are very significant to understanding possible origins of flood basalts and are thus pertinent to any model of global tectonics.

Magma chamber "plumbing" and behavior are complex beneath Krafla, Hekla, and other volcanic centers (Einarsson and Björnsson, 1980; Feigl et al., 2000; Sturkell and Sigmundsson, 2000). Hekla, with its regularity of eruption and progression from highly developed (calc-alkaline and intermediate) to less developed (basic) lavas during eruptions, lends credence to the concept of relatively rapid differentiation in magma chambers (Guðmundsson et al., 1992). Nonetheless, this alone cannot explain the observed lithologies when the assumed parent magma is a MORB-like tholeiitic basalt (Jakobsson, 1980) without invoking crustal recycling (Oskarsson et al., 1985) or complex mixing of sources. The assumption of mantle homogeneity is more than a long-standing simplifying assumption; it is based on belief in the nebular hypothesis (Snelling, 2000). Data increasingly indicate this assumption is wrong (Anderson, 2001; 2002; Batiza and White, 2001; Lassiter and DePaolo, 1997; Oskarsson

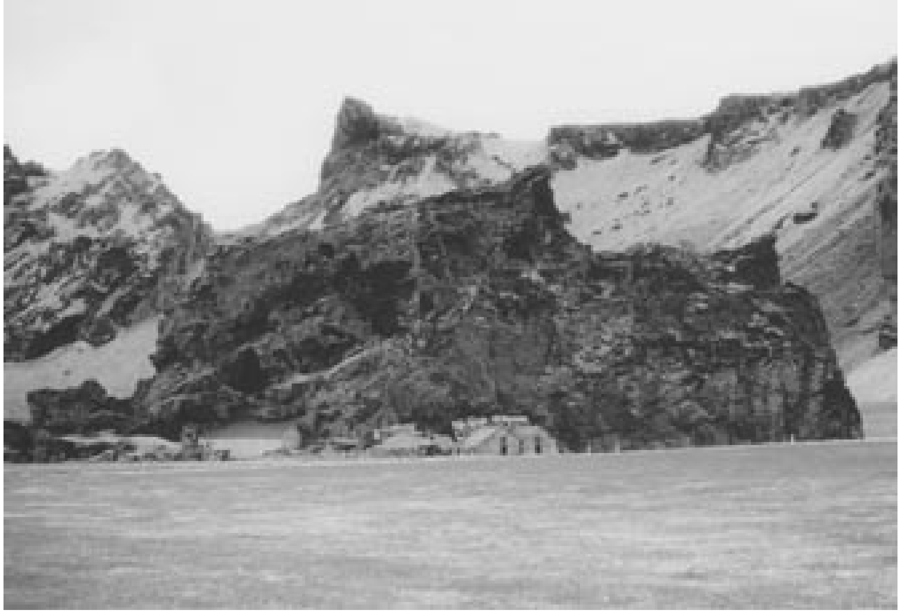


Figure 13. Topographic development in the modern environment, such as this at Drangshlíð, is very evident on the present surface but seldom seen in the rock record.

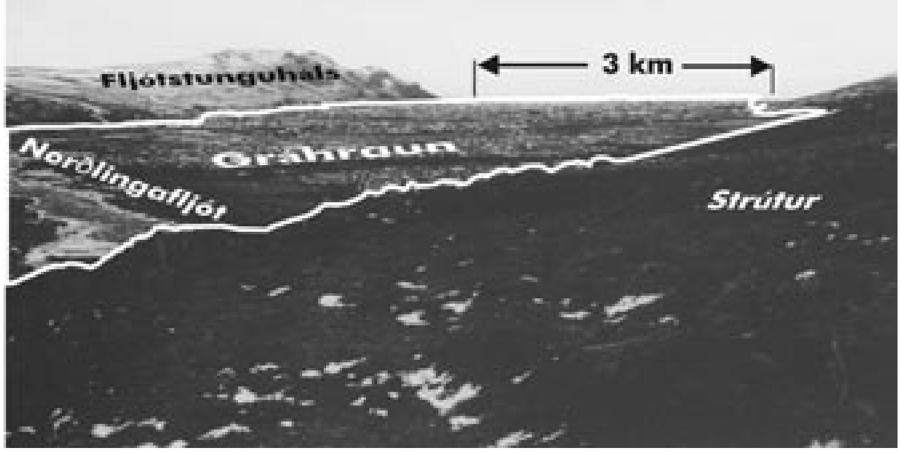


Figure 14. Gráhraun, a pahoehoe flow from ca. A.D. 880. View toward northeast with flow outlined in white. Note that flow fills valley bottom and has diverted the river (Norðlingafljót).

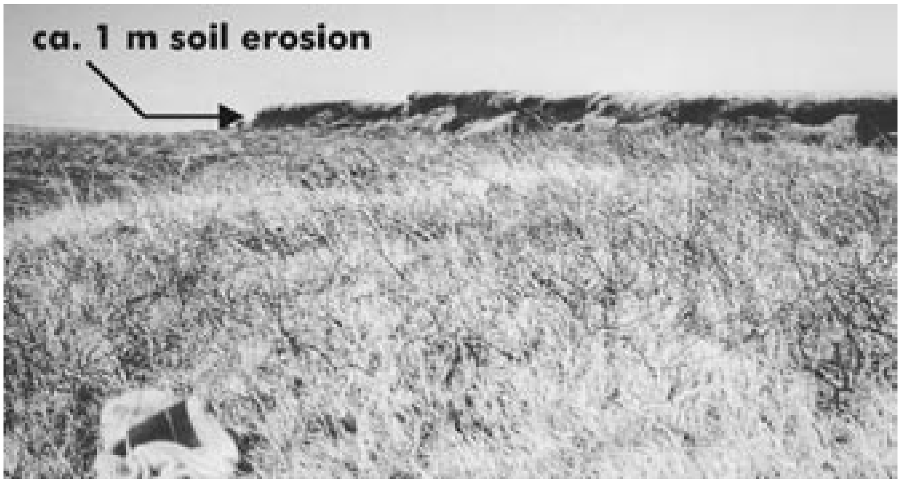
et al., 1985; Saunders et al., 1997; Snelling, 2000). Since the crust has always been heterogeneous (Genesis 2:11, 12; 4:22), the mantle may also be heterogeneous. In general, Iceland's lithology is amenable to explanation as derivatives of MORB or possibly plume-derived magmas from a heterogeneous mantle.

Much of the lava pile is described as "subaerial" (Fridleifsson, 1980; Jóhannesson and Sæmundsson, 1998; Sæmundsson, 1980), though there is good reason to question this (Froede, 2000). Where pillow lavas, hyaloclastites, and palagonite are encountered, these are invariably interpreted as subglacial (Jakobsson, 1980). Marine fossils indicative of warm (nonglacial) environments are present in sediments at Tjörnes, and igneous fossils of plants have been reported from several locations (Símonarson, 1980). Unconformities between the flood basalts and subsequent strata are reported from Snæfellsnes (Figure 4) and Skagi, but are rare in Iceland (Sæmundsson, 1980). In general, there is no evident hiatus between the flood basalts and lavas up section (Figure 5), which follow the volcanic zones in the center of the country (Jakobsson, 1980). Diluvialists are more inclined to accept the possibility of subaqueous emplacement and fossilization of organisms not native to the modern environment, while adherents of the establishment geological paradigm (EGP) can be expected to favor subaerial interpretations and climatic fluctuations over vast ages.

As shown in Figure 3, Iceland sits astride the Mid-Atlantic Ridge at the center of the NAIP. According to the EGP, rocks in western Greenland and the British Isles are that province's oldest, approximately 50 to 60 Ma. Lithologically, these rocks and those elsewhere in the NAIP reportedly exhibit variations similar to those observed in Iceland (Saunders et al., 1997), consistent with my limited observations (Figure 18). Presumably, these rocks are related to a common source. Evolutionists and creationists disagree about the time required for emplacement. Old ages are based on natural history assumptions and radiometric "ages," concepts neither scientifically valid nor compatible with the diluvial geological paradigm (DGP) (Malcolm, 1997; Middelmann and Wilder-Smith, 1980; Reed, 1996; 1998; 2000a; 2001; 2003; Vardiman et al., 2000; 2005; Woodmorappe, 1999a; 1999b).

Inferring Time Required for Emplacement

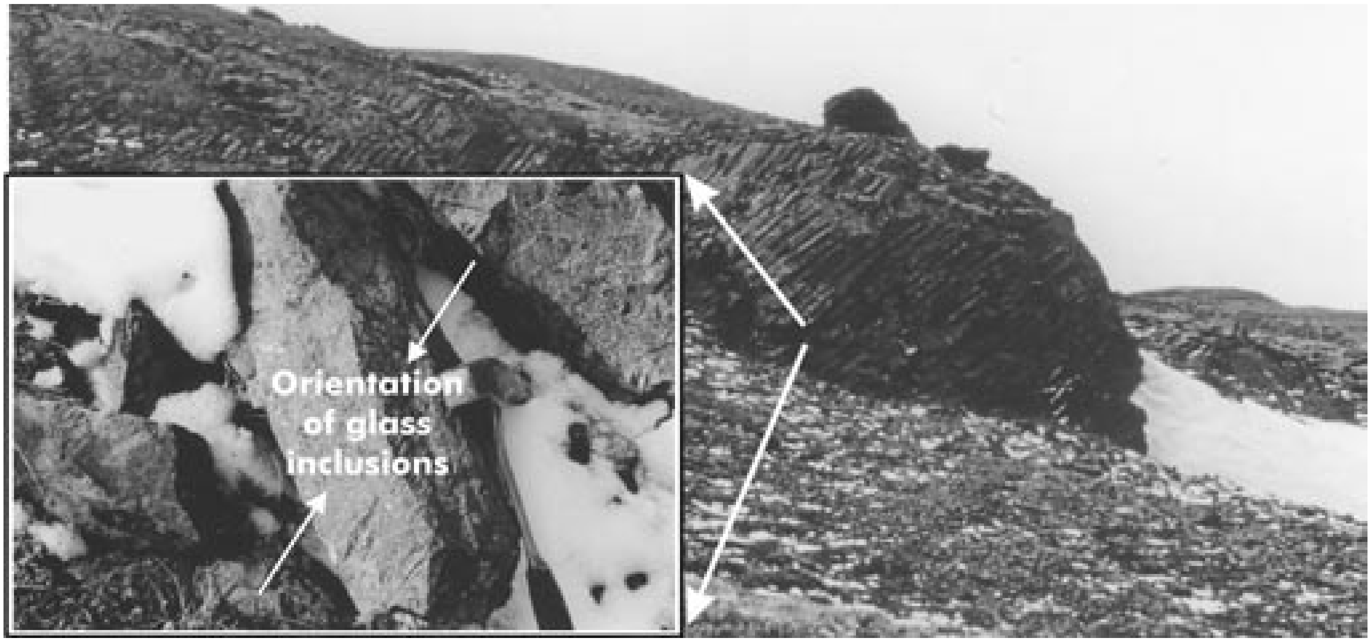
The time required for Iceland to form requires: (1) a long-term average extrusion



above: **Figure 15. Approximately one meter of soil has been eroded by anthropogenic and aeolian factors on Hafurshorn west of Hekla.**

above right: **Figure 16. Pedogenesis pioneered by lichens and mosses is evident on the 1766-1768 lava flow on the southwest flank of Hekla.**

below: **Figure 17. Columnar dacite with glass inclusions, Tunga, Reykholtsdalur in western Iceland.**



rate and (2) the total extruded volume. The first is impossible to determine; the second is slightly more tractable. Science is useful to this speculation by setting upper and lower bounds on the time of formation by using suitable assumptions and historical data from flows (Þorarinson and Sæmundsson, 1980).

Many eruptions in Iceland and other places around the world have been studied and either direct measurements or fairly reliable estimates obtained for extrusion rates and other properties. Eruptions observed in Iceland have been from both fissures and volcanic

Table II. Summary of Lava Extrusion Rate Observations

Flow	Date	Composition	Vent Type	Extrusion Rates (m^3/sec) *		Unit Rate (m^3/sec per meter length)	
				Min.	Max.	Min.	Max.
Hekla [1,2,3,4]	1104	mostly calc-alkaline basalts, but also basaltic andesite, andesite, dacite, and rhyolite (larger eruptions more basaltic); forms block flows					
	1206						
	1222						
	1766-68						
	1845						
	1878						
	1913						
	1947		<7 km fissure				
	1970		½ - 25 km fissure	2.5	7,500	*0.01*	0.30
	1980		7 km fissure	1,160	2,300	*0.16*	0.33
	1981		fissure	*50*	100		
	1991		fissure	*2,000*	1	*0.02*	*8.00*
Laki [2,4] (estimated initial)	1783 to 1784	fluid basalt, yet block flows resulted	≤27 km fissure	*5,000*	*9,000*	*0.19*	*0.60*
Laki [4,5] (8-month avg.)				570	840	*0.02*	*0.03*
Krafla [1]	1724–29	"very fluid basaltic lava" forming smooth or pahoehoe flows	fissure				
	1976–78 subterranean		magma chamber	*4*	*5*	subterranean activity only	
	3/1980		4.5 km multiple fissures	120	360	*0.03*	*0.16*
	7/1980		4 km multiple fissures	*75*	*150*	*0.02*	*0.08*
	10/1980		0.2–0.3 km fissure	*50*	*200*	*0.17*	*1.00*
	11/1981		½–8 km en echelon fissures	*30*	*100*	*0.00*	*0.20*
	1980–1984 average of five flows		½–8.5 km multiple fissures	90	100	*0.01*	*0.18*
Eldfell, Heimaey [5] (Vestmannaeyjar)	1973		4 km fissure	40	50	*0.01*	*0.10*
Eldgja [2]	940		fissure	*500*	*15,000?*	*0.05*	*0.50*
Iceland Historical Average [4,5]	874 to 2002	basalt	all (mostly fissure)	0.90	?	*1.33*	*2.50*
Kilauea, Hawaii, U.S.A. [4]	1983 to present	basalt, both a'a and pahoehoe flows	crater: 250 m by 400 m	0.01	*24.0*	0.00	*0.01*
Kilauea, 19-year average [4]				3.8	3.8	0.01	0.01

Table II (continued). Summary of Lava Extrusion Rate Observations

Flow	Date	Composition	Vent Type	Extrusion Rates (m^3/sec) *		Unit Rate (m^3/sec per meter length)	
				Min.	Max.	Min.	Max.
Etna, Sicily, Italy Estimated long-term average[4,6]	probably most of post-diluvian time (to present)	tholeiitic basalt to trachyte	mostly radial fissures	*0.30*	*0.30*	*?*	*?*
Etna, Sicily, Italy Observed modern rates[4,7]	1971		fissure	*7?*	13	*?*	*?*
	1991 to 1993		1 km? fissure	5	6	*0.00*	*0.00*
	1999 S.E. Crater		crater: <250 m diameter	5	5	*0.02*	*0.02*
Columbia River Basalt Group[2,8]	diluvial?	basalt, smooth (flood) flows	multiple fissure	*4,000*	*1,200,000*	*0.04*	*12.00*
Arenal, Costa Rica[2,9]	1968 to 2000	andesite, some a'a-block, but mostly block flows	crater: <500 m diameter	0.24	*0.50*	*0.00*	*0.01*
Mount Saint Helens, Washington, U.S.A.[4]	1980 to 1986	dacite plug dome	crater: 365 m diameter	0.70	23.7	*0.00*	*0.06*

Sources: [1] McClelland et al., 1989; [2] Bardintzeff & McBirney, 2000; [3] Guðmundsson et al. 1992; [4] Pyle, 2000; [5] Zeilinga de Boer and Sanders, 2002; and Saunders et al., 1997; [6] Walker, 2000; [7] Behncke, 2001; [8] Shaw and Swenson, 1970 (high value); [9] http://www.arenal.net/arenal-volcano-overview.htm.

craters and include tholeiitic basalt and transitional alkali basalt lavas. Data from these eruptions are relevant to long-term volcanic behavior in Iceland. Data from other places are useful for comparison, particularly to assess the role of vent geometry and lithologic composition on extrusion rates.

Some flows, particularly flood basalts of large igneous provinces (Table I), have no historic example of an eruption. Their behavior can only be inferred by extrapolating from historic data and applying the tools of physics and geology, especially the principles of fluid mechanics. Diluvialists have done preliminary work on both the Columbia River Basalt Group (Nevins, 1974; Woodmorappe and Oard, 2002) and the North American Midcontinent Rift System (Reed, 2000b), though work remains to be done on these and other large igneous provinces. Extrusion rate estimates of these unobserved flows often exhibit uniformitarian bias and are less useful than historic data. All Icelandic flood basalts predate the *Landnám*.

Table II provides a summary of lava extrusion rate data from several sources. Data are expressed both in terms of total extrusion rate and unit extrusion rate (rate per unit length of vent). They are presented to show the relationships between vent type and size, rock type, and extrusion rate. Not surprisingly, fissure eruptions tend to release larger volumes of lava in a given time than crater eruptions. Craters may be associated with sialic, intermediate, or mafic lithologies, but fissure eruptions are typically associated with mafic lavas. The largest extrusion rates are from basalt fissure eruptions, which differ enormously in total extrusion rate, but much less in unit extrusion rate. Tabulated values of minimum and maximum rates of extrusion per meter of fissure length from eruptions of Krafla range from 0.01 to 1.00 m^3/s. Other historic flows in Iceland, including Lakagígar, fall within this range.

Table II supplies part of what is needed to approximate an average extrusion rate. Other needed variables are: (1) the fraction of total time during which eruptions occurred, and (2) the length of active vent. My assumptions and

Figure 18. Flood basalts are evident in the east coast of Stremöy, Færöyane. Photograph taken from approximately one km at sea in typical Færoese weather.

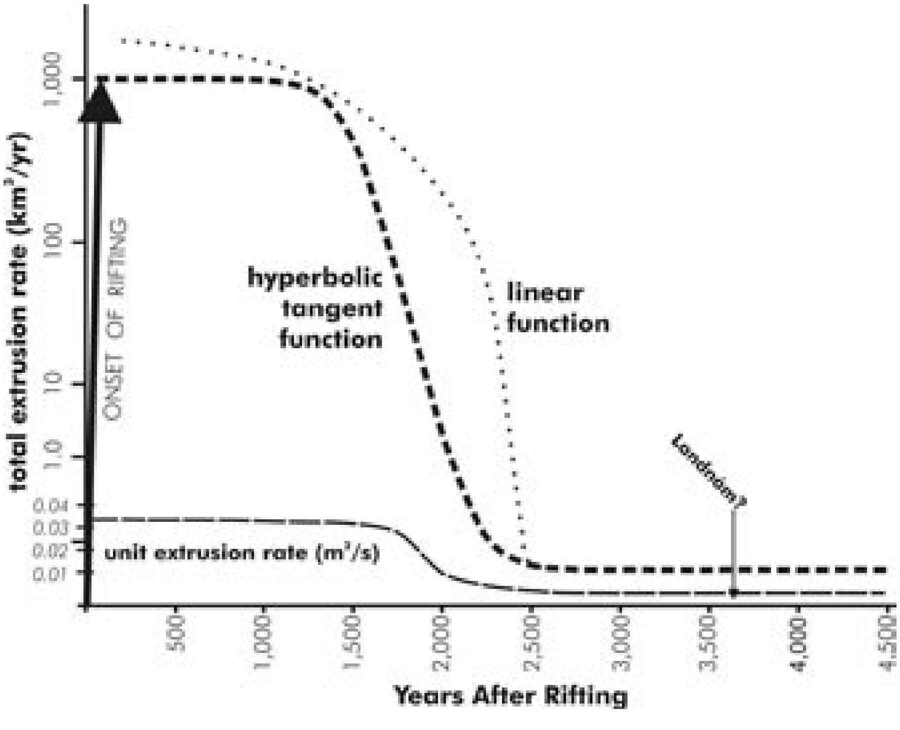


Figure 19. Hypothesized lava extrusion rate functions for emplacement of Iceland.

methods are summarized in Appendix B. The primary limit is that the total amount of time for Iceland's formation cannot be less than the amount of time required to extrude that volume of lava, though it may be more. Additional time can only be inferred from the character of contacts: the longer the time of quiescence, the greater will be the extent of erosion and sedimentation, topographic development, weathering, and soil formation.

Table III summarizes my analysis of lava extrusion parameters. The first two figures are unrealistic extremes. Based on the historic average rate of lava production (Þorarinson and Sæmundsson, 1980), approximately 56.4 Ma would be required to form Iceland. Yet its age is generally believed by evolutionists to be less, about 21 Ma (Sigurjónsson and Tulinius, 2001). Any calculation must address the fact that historic flows differ greatly from earlier ones. Modern flows are mostly block flows; pre-*Landnám* flows are mostly flood basalts, which form rapidly; four years for formation is the minimum published estimate for the Columbia River Basalt Group (Shaw and Swanson, 1970). This is unrealistically short, since not all of the rocks of Iceland are flood basalts. However, since such a large volume of Iceland does consist of flood basalts, shorter time estimates appear more plausible than evolutionists' guesses.

More realistic estimates can be obtained by estimating the percentages of various types of flows, respective fissure lengths, and appropriate unit discharge values. The second pair of time estimates used minimum unit extrusion rates and minimum estimated fissure length to obtain the maximum time, and maximum discharge and fissure length to obtain the minimum time. These estimates are both tighter and more realistic, ranging from under 2,000 to 15,000 years.

In general, lava eruptions tend to exhibit two important trends: (1) initial near maximum discharge gradually declines, and (2) fissures tend to concentrate into localized vents (Þorarinson and Sæmundsson, 1980). Thus, for fissure eruptions, unit discharge may actually increase while the total extrusion rate falls. To reflect this tendency, a third

Table III. Estimated Time for Emplacement of Iceland

Scenario	Years to Form
Total time to form lava pile based on historic average extrusion rate	56,400,000
Total time based on maximum published estimate for CRBG[1]	4
Time based on minimum fissure length and minimum extrusion rate	15,000
Time based on maximum fissure length and maximum extrusion rate	1,819
Time based on minimum fissure length and maximum extrusion rate	3,706
Time based on maximum fissure length and minimum extrusion rate	6,415
Age of Iceland based on evolutionist (EGP) scenario[2]	21,000,000
Age of Iceland based on biblical history (DGP)	4,500

[1] See Table II.
[2] Sigurjónsson and Tulinius, 1994, p. 133.

pair of total time estimates was generated by pairing minimum discharge with maximum effective fissure length, and maximum extrusion rate with minimum fissure length. The resulting total time estimates are approximately 3,700 to 6,400 years.

Table III's final pair of numbers compare the predictions of the EGP and DGP for the age of Iceland. The time required for lava extrusion must be less than or equal to any presumed age for Iceland. Although the most realistic estimates in Table III are compatible with the 4,500-year strict biblical chronology, this does not "prove" that Iceland formed in 4,500 years. But if it took 21 Ma, volcanism was quiescent for approximately 99.98 percent of that time. Science is only useful in testing historical scenarios, not in generating or "proving" them (Klevberg, 1999; 2000a; 2000b; Reed, 1998; 2000a; 2003; Reed et al., 2004). However, the analysis showed that Iceland could have formed within the time constraints of either the DGP or the EGP. Thus, the extent of quiescent time must be tested to differentiate between the two models. This can be done by evaluating evidence of significant hiatuses in the form of contacts marked by features requiring substantial time to form—the DGP predicts their absence; the EGP the opposite.

Plausibility of DGP Scenario for Age of Iceland

Table III provides conservative estimates corresponding to the DGP's anticipated age for Iceland, based on data and methods from Table II and Appendix B. I devised the models displayed in Figure 19 to better constrain the parameters and reflect general eruption trends, especially the tendency for initially prolonged outpouring of flood basalts (Hooper, 2000). These models are speculative; they therefore implicitly incorporate the estimated total extruded volume, the historic average lava discharge rate, and the expected 4,500-year history of the DGP.

Probably the greatest break these models make with the EGP is the initial extrusion rate. The linear function included in Table IV and Figure 19 is simple, but does not appear to resemble the actual history of Iceland since it does not mimic the kind of decline in discharge with time typical of eruptions, and because its arbitrary threshold is the modern value. The more complex hyperbolic tangent function, also included in Table IV and Figure 19, appears more realistic. Its first inflection point marks the end of flood basalt emplacement; the second represents a transition to current conditions (end of glaciation isostatic adjustment?). A higher initial extrusion rate followed by more rapid, exponential decrease might be more realistic (Sigurdsson, 2000b), and glaciation and deglaciation would likely produce subsequent episodes of increased volcanic activity, but without historical control, such "fine tuning" is unwarranted. Thus, while other models could be devised; most should resemble the hyperbolic tangent function.

But are these models plausible? Are their initial rates realistic? The estimated initial lava extrusion rate for these models is enormous (Table IV). It is easily

Table IV. Postdiluvial Emplacement Scenario for Iceland

Parameter	Value	
	Hyperbolic Tangent Function	Linear Function With Threshold
Assumed date of initial eruption	2498 B.C.	2498 B.C.
Maximum initial extrusion rate (total) in m^3/s	33,778	30,290
Maximum initial extrusion rate (unit) in m^3/s per m	0.03	0.03
Historic average extrusion rate (total) in m^3/s	0.90	0.90
Time for emplacement of half of total volume, years	750	981
Approximate date predicted to reach sea level	1575 B.C.	1230 B.C.

four times higher than the initial extrusion rate for the Lakagígar eruption, and the discharge for the hyperbolic tangent (nonlinear) model would decline only gradually at first. However, the picture changes dramatically when one begins with the assumption that Iceland was simply an arbitrary 1,000 km stretch of the Mid-Atlantic Ridge. Thus, the *unit* discharge would have been a mere 0.03 m^3/s, equal to the eight-month average rate for Laki and well within modern values (Table II). This value may actually be too *low* based on estimates for flood basalts from other large igneous provinces.

Figure 19 and Table IV predict that half the volume of lava constituting Iceland would have been extruded in the first 750 to 1,000 years. Today's sea level would have been reached in 900 to 1,300 years, meaning the age of Iceland as an island (or group of islands) would be approximately 3,300 to 3,600 years. Total annual lava discharge would decrease with time. If one assumes the average flow thickness is 4 m (flood basalts average 5 m to 15 m according to Sæmundsson, 1980), decades could pass between flows after Iceland emerged from the sea, and even centuries could pass approaching *Landnám*. Based on modern erosion and sedimentation processes in Iceland and rates of soil formation observed elsewhere (Klevberg and Bandy, 2003a; 2003b; Klevberg et al., 2003; Sæmundsson, 1980), one could expect to see evidence of topographic relief, sedimentary deposits, and soils preserved beneath at least some of these flows. However, as stated above, such evidence is not often apparent, especially in the eastern and western parts of the country. Hornitos are present in some parts of the country; paleosols are no doubt present beneath some of these lava flows.

Soil formation would have been minimized by the presence of ice. If most of Iceland were glaciated for much of its history, the period of time available for pedogenesis would have been greatly reduced. However, if parts of Iceland were nonglaciated for centuries or millennia, deep weathering horizons and soils should be present locally. The number of paleosols would be much reduced by glaciation, but a long history would inevitably produce many recognizable paleosols (unless Iceland was mantled by glaciers for most of its history).

Paleosols and weathered horizons would also be minimized by soil erosion. Iceland has experienced severe soil loss due to wind erosion (Sigurjónsson and Tulinius, 2001), but much of this has resulted from overgrazing and use of four-wheel-drive automobiles in recent times. Prior to *Landnám*, the country was well vegetated with good soil cover (Sæmundsson, 1980). Soil erosion has been largely anthropogenic, though exacerbated by climate change (Dugmore and Buckland, 1991; Gerrard, 1991). Loss of soil would tend to accelerate erosion-sedimentation processes and topographic development. Wind erosion might also transport some of the fine particles into the sea, skewing the sediments trapped between lava flows toward the coarse particles. Evidence of hiatuses would therefore simply differ in character—unconformities instead of paleosols.

Despite these difficulties, peat and loessal soils have been observed to form rapidly, "which means that the soil cover thickens so quickly that tephra layers of small difference in age are separated in the soil sections" (Þorarinsson, 1980, p. 164). This makes tephrochronology possible, though EGP presuppositions may result in unrealistically low estimates for pedogenesis rates. Investigations at

Vatnagarður near Hekla are considered typical, with soil formation rates of 0.1 to 5 mm per year excluding tephra (Þorarinsson, 1980). Documentation of these observations began in 1638 (Þorarinsson, 1980, p. 162). While pedogenesis in the initial century or two may be very slow (Caseldine, 1987), this rate accelerates significantly thereafter (D'Orico, 2000; Klevberg and Bandy, 2003a; 2003b; Klevberg et al., 2003).

The lack of widespread evidence for hiatuses between eruptions remains problematic for the EGP. This disparity could have resulted from significant past climate change (e.g. an ice age), the highly permeable character of many lava flows, or some other variable, but it may also indicate that the models shown on Figure 19 predict too little volcanic activity approaching *Landnám*. Alternatively, the age of Iceland may be even less than predicted by these DGP models. The volume of lava believed to have been extruded since deglaciation (Jakobsson, 1980) would correspond to extrusion since 260 B.C. (approximately 2,235 years after rifting) in this model, and variations in extrusion rate could be expected from isostatic readjustment during glaciation and deglaciation (Zielinski et al., 1997). An ice age of significant extent could be expected from climatic and geographic conditions resulting from the Deluge (Oard, 1990).

Plausibility of EGP Scenario for Age of Iceland

The EGP predicts an age for Iceland of roughly 21 Ma for the islands and 62 Ma for the beginning of the NAIP (Saunders et al., 1997). Even with the generous estimate of 15,000 years for emplacement of the lava pile (Table III), approximately 99.97 percent of the 21 Ma would have been volcanically quiescent. If the average depth for each lava flow was 4 m, the average amount of time that the surface of a given flow would have been exposed is approximately 54,000 years. Recognizing the more rapid discharges at the rift's opening and formation of flood basalts, the time of each flow's exposure after Iceland emerged from the sea would have been even greater. During this time, sedimentation and erosion would have occurred, topography would have developed, and at least several meters of soils would have formed. These factors would act in decades or centuries, not millennia! It is difficult enough to explain the apparent paucity of paleosols and buried terrain with the DGP model, but time in EGP models is multiplied by four orders of magnitude. Appeals to destruction of surfaces by fresh lava are contradicted by the existence of igneous fossils, the preservation of such surfaces in other parts of the world, and the sheer depth of the weathering horizon that should have resulted from 10^5 years of exposure. The end of the "Pleistocene" ice age would have been approximately 10,000 years ago (end of Búði, equivalent to Younger Dryas [Björnsson, 1980, p. 206]), meaning that weathering processes would have been active for at least this long for most of Iceland. Even longer interstadials and warm periods would have existed in the more than 20 Ma widely accepted as Iceland's age. Erosion of exposed surfaces would have produced well-developed topography through multiple cycles. The eroded detritus would have been deposited as unconsolidated sediments, possibly lithified or metamorphosed by overtopping lava flows. Sediments in Iceland are a minor portion of the total and consist primarily of coarse, unconsolidated deposits and volcanosedimentary interbeds in flow successions.

Iceland is an example of the inadequacy of the EGP in igneous terranes. Similar failures of the EGP have been noted in the North American Mid-Continent Rift System (Reed, 2000b; 2002b) and the Columbia River Basalt Group (Woodmorappe and Oard, 2002). Similar EGP difficulties arise in sedimentary terranes (Lalomov, 2001; 2003; Lalomov et al., 2003; Lalomov and Tabolitch, 1996; Reed, 2002a; 2002b; 2004; Snelling, 1992). This lends credence to the thesis that *deep time is illusory*. Instead of bolstering the EGP, appeals to radiometric "dating" call these methods into question. "Dating" methods by definition depart the realm of science and enter that of history lacking a proper philosophical foundation (Reed 1998; 2000a; Reed et al., 2004). Discrepancies with these methods have been noted (Molén, 2000; Vardiman et al., 2000; Woodmorappe, 1999a; McBirney, 1993). Iceland further discredits radiometric methods, since the ages obtained by them compound the problems caused by the disparity between lava extrusion rates and inferred age.

Where Has Iceland's Mantle Plume Gone?

Iceland was an early star in the triumph of the plate-tectonics theory, appearing to confirm several of its key elements. The coincidence of the Mid-Atlantic Ridge rift and the Iceland hot spot produced enough lava to form the islands of Iceland (Jakobsson, 1980; Saunders et al., 1997; Sæmundsson, 1980). Hot spots have long been a basic component of plate-tectonics theory, resulting from relatively stationary plumes deep within the mantle, perhaps as deep as the core-mantle boundary. They "burn holes" in lithospheric plates as the plates move over them, leaving a trail of volcanic rocks that are "dated" and used to infer the direction and rate of movement of tectonic plates (e.g. the Hawaiian Islands-Emperor Seamount lineament). However, the traditional explanation for hot spots has been recently criticized (Baksi, 2001; Froede, 2001; Sheth, 2005; Stock, 2003; Tarduno et al., 2003).

Hot spots are often associated with large igneous provinces—entire regions dominated by igneous rocks on a scale not witnessed in modern environments.

Some (Simken and Siebert, 2000, p. 255; White and McKenzie, 1989) believe that these areas, particularly those covered by flood basalts, represent the initial "burn-through" of a hot spot (i.e. decompression melting as rifting is triggered), with less rapid emplacement as the hot spot "settled down." These provinces, like island chain tracks, are used as evidence for plate tectonics. Arguments for uniformitarian plate tectonics have been subsumed into catastrophic plate tectonics (CPT), which proposes highly accelerated, non-uniform plate motions during the Noahic Flood (Austin et al., 1994). While some are critical of CPT (Froede, 1998; 1999; Hohensee et al., 2002; Reed 2000b; 2000c; Baumgardner and Oard, 2002) and alternatives exist (Oard, 2001a; 2001b), CPT is probably the majority opinion in creationist circles.

Although Iceland has long been used as an example of a hot spot, recent geophysical data may call into question the existence of a narrow cylindrical plume of hot rising mantle beneath Iceland. Analysis of geophysical surface wave, receiver function and tomography data, in combination with gravitational data, indicate that the crust beneath Iceland is thicker than previously thought (Oskarsson et al., 1985), though often difficult to define (Du and Foulger, 2001; Du et al., 2002), and that a dike-like magma conduit extends no deeper than the mantle transition zone beneath Iceland's Middle Volcanic Zone (Du et al., 2002; Foulger et al., 2000; 2001; Pritchard et al., 2000). Researchers have been reticent to acknowledge it, exemplifying the "reinforcement syndrome." Foulger et al. (2001) stated:

> Much of the seismic evidence for a plume in the lower mantle beneath Iceland consists of observations of types that either are found elsewhere unaccompanied by hotspots or are not found beneath known hotspots. Many studies specifically seek a narrow, vertical, cylindrical body with a relatively strong anomaly, and the results tend to be interpreted in these terms if possible, although the observations may be consistent with other hypotheses. (p. 528.)

Helium isotope studies (Anderson, 2000; Foulger and Pearson, 2001) indicate that isotopic ratios previously interpreted as deep mantle signatures are probably related instead to relative abundances of uranium and thorium. Partial melting and changes in mineralogy, temperature, and bulk density can all affect seismic velocities (Funamori et al., 2000) and be misinterpreted as an upwelling mantle plume.

Researchers now conclude that the hot spot has not been fixed relative to a particular location on earth or to the core or lower mantle, but has rather been more or less fixed relative to the Mid-Atlantic Ridge and Iceland (Foulger et al., 2001), or has migrated eastward relative to the plate boundary (Oskarsson et al., 1985). Despite a vigorous defense by the "plumatics" against the "aplumatics" (Campbell, 2005; Parkin et al., 2007; Saunders et al., 2003; Wolfe et al., 1997), doubt has settled on the traditional plume theory in Iceland (Einarsson and Björnsson, 1980; Jakobsson, 1980), as well as at other hot spots around the world (Baksi, 2001; Christiansen et al., 2002; Sleep, 2004; Stock, 2003). While aplumatics may accept the basic concept of plate tectonics, they also entertain alternative tectonic theories (Lunde, 2001; Sheth, 2005; and others, notably Don Anderson). The arguments of the "plumatics" are invariably entangled with uniformitarian assumptions.

Perhaps the best current understanding of the Iceland hot spot consists of a magma source in the upper mantle with a north-south tabular seismic anomaly that becomes cylindrical at a depth of about 250 km. Its center is believed to lie in eastern Iceland or perhaps in the Middle Volcanic Zone northwest of the traditional center location of Vatnajökull. Complex "plumbing" feeds Krafla, Hekla, and other active volcanic centers (Allen et al., 2002; Einarsson and Björnsson, 1980; Feigl et al., 2000; Sturkell and Sigmundsson, 2000). Magma flows toward Reykjanes Ridge in the south but is blocked to the north by the Tjörnes Fracture Zone (Jakobsson, 1980). Crustal structure is relatively complex, with no distinct Moho in some locations. A "complex, unstable, leaky microplate tectonics" model has been proffered to explain the hot spot (Anderson, 2001; Foulger and Anderson, 2005) or "hotcells" rather than a traditional plume (King and Anderson, 1995), and magma forms as partial melts, possibly from decompression melting (Saunders et al., 1997). However, there are problems with these theories. Just the same, Iceland does represent a hot spot in the plainest meaning of the term–a region of unusually active volcanism (Jakobsson, 1980).

Is Iceland Coming Apart or Just Our Theories?

The "plume wars" are not the only problem Iceland presents to current theory. Palagonite and tuyas, once interpreted as evidence of glaciation, are now recognized to form in subaqueous (marine) environments, too (Jakobsson, 1980; Þorarinsson and Sæmundsson, 1980), especially shallow water (Batiza and White, 2000), challenging part of the basis for multiple glaciations. Increasing evidence of mantle heterogeneity challenges long-held suppositions underlying interpretations of isotopic ratios. Lava extrusion rates and Iceland's structure present problems for uniformitarian geochronology and plate tectonics, and offer an opportunity to test predictions of CPT.

Plate motion at the Mid-Atlantic Ridge and Iceland is "known" to be approximately 2 cm/yr of extension (Feigl et al., 2000; Hreinsdóttir and Einarsson, 2001; Jónsson et al., 1997; Sigurjónsson and Tilinius, 2001; Stesky, 1997). However, Iceland does not show a "hotspot track" in the manner of Hawaii or Reunion by which to infer plate motion. Iceland consists of a main landmass and smaller islands, with only the relatively subdued Greenland-Færöe Ridge and no series of seamounts tracking the movement of the North American and Eurasian plates. The elevated plateaus and ridges of the sea floor near Iceland are thought to result from thermal anomalies (Oskarsson et al., 1985). North American and Eurasian plate motions are inferred from radiometric "dates" and model-based speculation. Yet Iceland holds one advantage over many other spreading centers: it is above sea level. Increasingly precise distance surveys have been conducted perpendicular to the rift zones over the past three decades using global positioning system (GPS) equipment (Jónsson et al., 1997). While these data (Figure 20) indicate extension in the mid to late 1990s, this was not observed at other locations elsewhere in Iceland (Hreinsdóttir and Einarsson, 2001; Sturkell and Sigmundsson, 2000), and overall motion measurements do not support simple extension (Bjarnason et al., 2002; Foulger and Anderson, 2005). More recent data (Geirsson et al., 2006) appear to confirm the traditional view, with local exceptions, but show magnitudes of vertical motions equal to horizontal ones and nonlinear responses to earthquakes, glacioisostatic motions, and even annual oscillations. The real basis for the confidence with which plate motions are asserted is evident from the statement of Geirsson et al. (2006, p. 16): "Since the NOVEL-1A model [plate motion model] is based on geological data spanning the last few million years, it appears that plate movements outside the deformation zones are steady on timescales ranging from weeks to millions of years." Millions of years means historical inference, not geological data.

Plotted on Figure 21 are three curves: (1) a "constant" (long-term average) spreading rate based on EGP assumptions, (2) an exponentially decreasing spreading rate curve based on CPT, and (3) a stochastic (irregular or episodic) curve fit to the 1967–1994 published data. The stochastic curve has no predictive value but is simply intended to fit the observed data. Plate tectonics curves predict past spreading rates to 4,500 and 50 million years, extrapolations from the data of 150 and 1.7 million times, respectively. Even if these data were more extensive, it is questionable whether the proposed curves could be adequately assessed, since lithospheric plates are not truly rigid (Sleep, 2004). Relative plate motions must be inferred by other means.

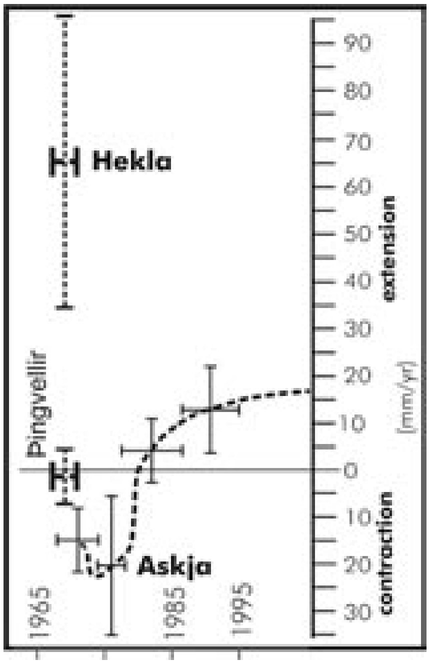


Figure 20. Observed relative plate motions for three sites in Iceland (a notable eruption occurred at Hekla in 1970.) Data from Jónsson et al., 1997; Sturkell and Sigmundsson, 2000.

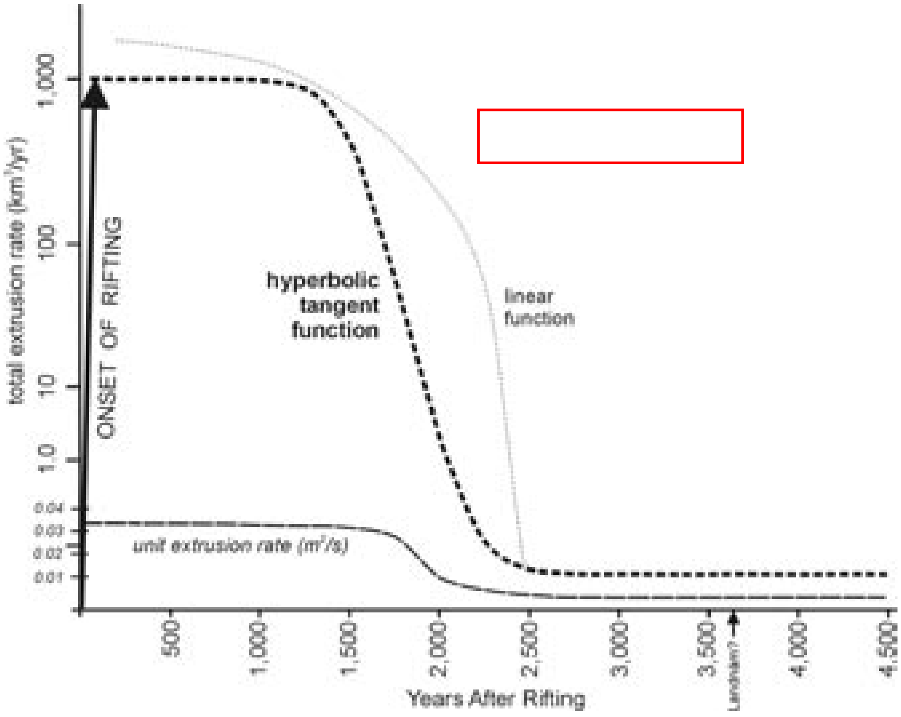


Figure 21. Comparison of three disparate historic plate motion scenarios. The accepted spreading rate between the North American and Eurasian plates is approximately 19 mm per year (Feigl et al., 2000, pp. 25, 655; Jónsson et al., 1997, pp. 11, 918), but the great disparity between this accepted value and observations has prompted some to look for a "leaky microplate" solution (Foulger and Anderson, 2005).

Commonly this is done by interpreting geomagnetic anomaly patterns on the sea floor. However, the paleomagnetic “stripes” are fraught with ambiguities (Merrill et al., 1998; Molén, 2000; Smith and Smith, 1993), the methods of analysis of the data are suspect, alternative interpretations exist (Klevberg and Oard, 2005; Merrill et al., 1998), and many if not most anomalies cannot be continuously traced to the Icelandic mainland (Kristjansson, 1980). Paleomagnetic reconstructions have proven problematic at other “hot spot” tracks (e.g. Emperor-Hawaii): “Similarly, some changes in the morphology of the geomagnetic field with time that have relied on fixed hotspots to anchor data from global sites are probably artificial” (Tarduno et al., 2003, p. 1068). Magnetic anomalies do not presently provide an adequate means of inferring plate motions, let alone rates.

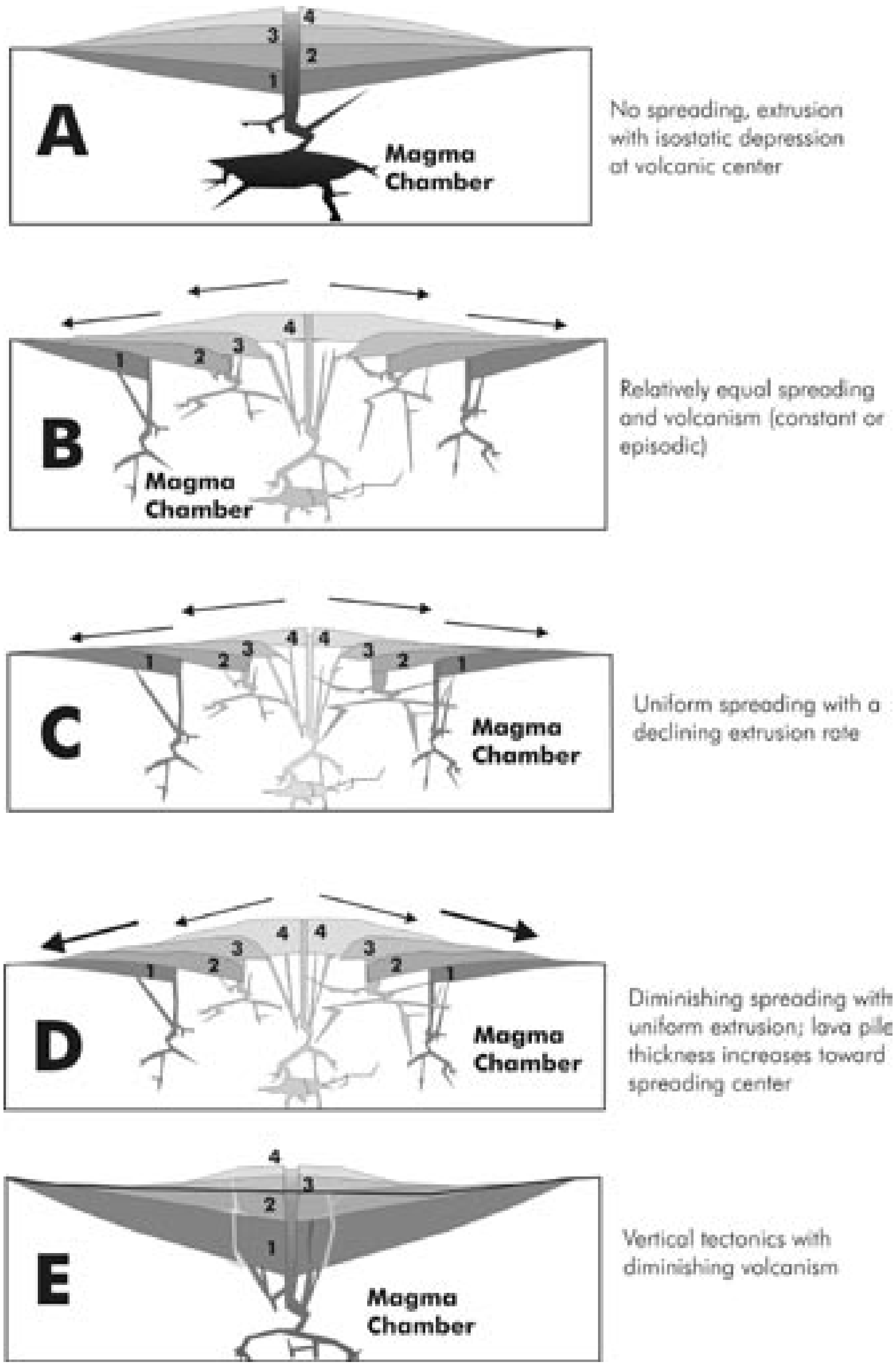

A
4
3
2
1
Magma Chamber
No spreading, extrusion with isostatic depression at volcanic center
B
1
2
3
4
Magma Chamber
Relatively equal spreading and volcanism (constant or episodic)
C
1
2
3
4
4
3
2
1
Magma Chamber
Uniform spreading with a declining extrusion rate
D
1
2
3
4
4
3
2
1
Magma Chamber
Diminishing spreading with uniform extrusion; lava pile thickness increases toward spreading center
E
4
3
2
1
Magma Chamber
Vertical tectonics with diminishing volcanism

Figure 22. Different responses to volcanism and plate motion. A = lava pile formed by extrusion with isostatic depression at volcanic center; B = lava pile formed by relatively constant spreading and extrusion; C = lava pile formed by declining extrusion and relatively constant spreading; D = lava pile formed by rapidly decreasing spreading; E = lava pile formed by primarily vertical tectonics with decreasing rate of lava extrusion.

Different models (Figure 22) will provide different predictions for development of a lava pile such as Iceland. Magma formed at depth will tend to move toward the surface. Where it erupts, it cools to form denser lava flows. Because of their greater density and the loss of material from the subsurface during the eruption, the flows tend to subside toward the volcanic center. Additional eruptions may deposit additional lava or tephra on the previous flows until the excess heat has been released and the magma supply is exhausted (Figure 22A). If this process occurs at a spreading center, the vertical progression will be combined with lateral displacements. If the long-term average rates of lava extrusion and plate movement are relatively constant, the lava pile will develop similarly to Figure 22B. If plate motion is constant but extrusion rates fall, the lava pile will tend to thin toward the center, where the pile is youngest (Figure 22C). If relative plate motion decreases more rapidly than extrusion, then the situation shown in Figure 22D would result. The EGP view of plate tectonics resembles Figure 22B. CPT predictions are less clear but would probably correspond to Figure 22D. If extension and lava extrusion declined at precisely the same rate, the result would be indistinguishable from the EGP prediction, and if lava ex-

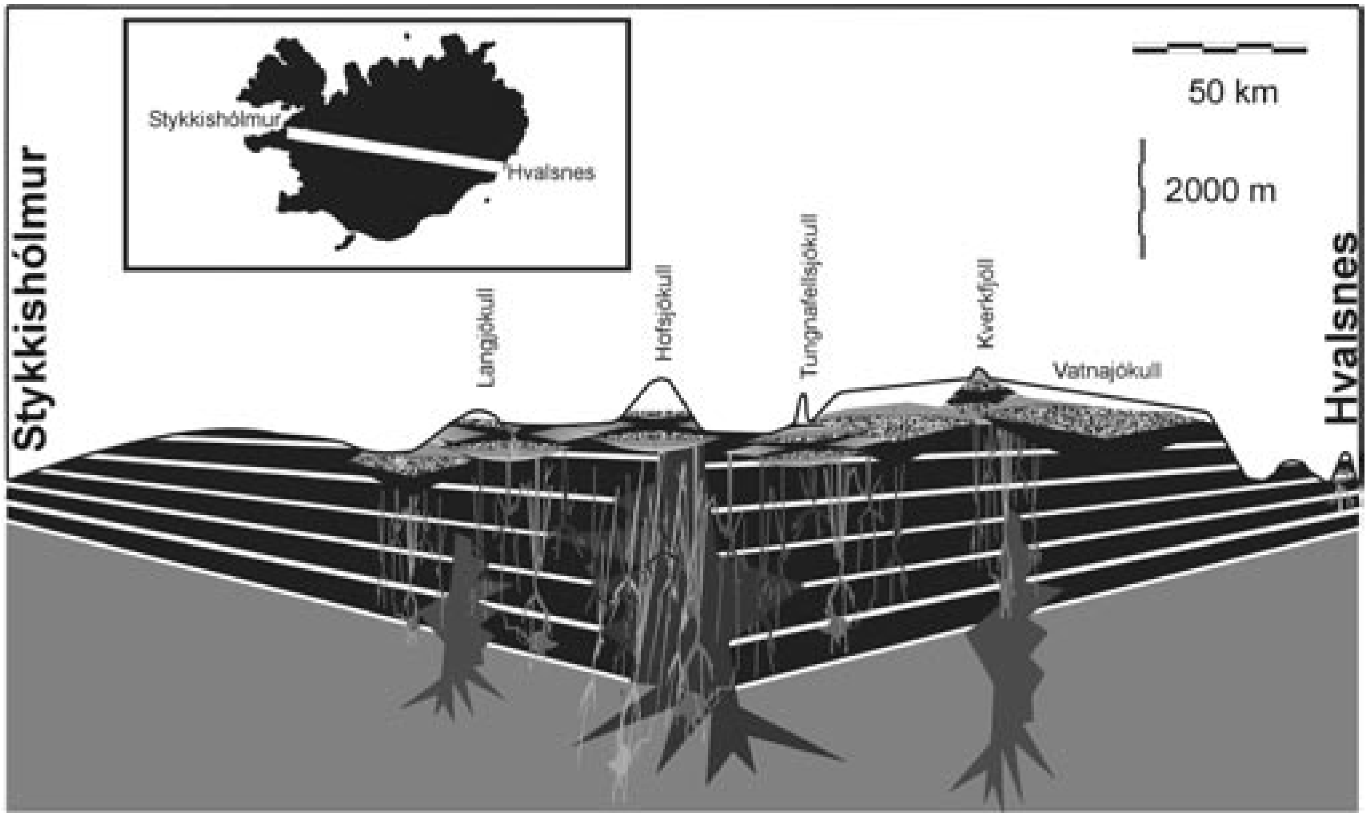


Figure 23. Simplified (cartoon) west-east section through Iceland.

trusion declined more rapidly than plate motion, the result would be closer to the situation illustrated in Figure 22C.

The actual structure of Iceland is, of course, more complex than these simple schematics. As shown in Figures 4, 5, and 23, the east, north, and west parts of the country–those most distant from the spreading center–exhibit vast flood basalt strata, while the flows near the spreading center are smaller. Flood basalts outcrop over half the country (Sæmundsson, 1980). This corresponds to neither Figure 22B nor Figure 22D. Nor does the lava pile thin in the manner of Figure 22C. Instead, the extrusion rate has fallen significantly since the flood basalts were emplaced. This, and the relatively thick crust under central and eastern Iceland (Oskarsson et al., 1985), may indicate that: (1) plate motion slowed during lava emplacement, (2) the rift and mantle plume interacted in a non-uniform fashion, or (3) plate motion was insignificant.

Figure 22E illustrates the expected lava pile structure under conditions of only vertical tectonics and a decreasing extrusion rate. According to Sæmundsson (1980, p. 136), flood basalts dip from near 0° near the top of the lava pile to about 5° to 10° toward the center of the pile at sea level, thickening conformably toward the center: "The regional tilt thus must have been imparted to the pile during its growth." This corresponds relatively well with Figure 22E.

What clearly has not occurred is the great passage of time under uniform conditions that has been the credo of most geologists over the past century and a half. Often this bias is tacit or even subconscious; occasionally it is not.

> Whatever their precise role in the history of the earth, these volcanic outbursts [flood basalts] can now take their place along with other geologic processes in the framework of uniformitarianism: the notion that the geologic past can be explained in terms of the same phenomena now shaping the earth. The unmatched scale of certain eruptions, notably the Deccan basalts, has led some workers to invoke causes outside normal earth processes–impacting asteroids, for example. But we do not think such catastrophes are required. Thick marine sequences of igneous rock, flood basalts on land and perhaps even mass extinctions–all can be explained by the interaction of familiar, ongoing earth processes (White and McKenzie, 1989, p. 71).

Despite assertions and reassurances

such as this, no extant EGP model can adequately explain the volcanic, pedologic, and tectonic features of Iceland. Uniformitarians ignore clear-cut evidence for rapid, catastrophic emplacement of the rock record and the "problem" duration of lava emplacement presents to "deep time."

Summary

Iceland provides an unusual opportunity to observe volcanic and tectonic processes usually obscured by the sea. Petrology and geochemistry, size and structure of the lava pile, and possible plate-tectonics explanations fit better with the DGP than the EGP.

While most of the lithologies of Iceland are tholeiites resembling MORB or MORB derivatives, differentiated lithologies and geochemical anomalies imply crustal recycling, fractionation in magma chambers, interaction with water, and mantle source heterogeneity. Diluvialists and uniformitarians differ primarily in the rates and relative importance assumed for these processes.

Much of the lava pile forming Iceland consists of flood basalts. These outcrop in the west, north, and east of the country. Large, conformable, inward-dipping strata indicate rapid emplacement of enormous volumes of lava. Lithologic uniformity of the flood basalts is a significant problem for uniformitarians.

> The differentiated character of such large masses of magma has presented a long-standing dilemma. Despite their great volume, the lavas were surprisingly homogeneous when erupted, and sequences of many flows maintain almost constant compositions, even though many centuries elapsed between eruptions. And yet these same flows differentiated, much in the way the ponded lavas of Hawaii have, in the periods of a few decades it took them to cool and crystallize. Eternal petrologic fame awaits the student who finds the explanation for this paradox (McBirney, 1993, p. 305).

The solution is both simple and obvious, but unacceptable to EGP adherents.

Up section and proximate to the rift are the volcanic zones, which are characterized by much smaller flows and greater lithologic diversity. EGP adherents insist on subaerial or subglacial emplacement for most of Iceland above sea level, while diluvialists can readily accommodate subaerial, subglacial, or subaqueous emplacement of all but the recent rocks. Paleontologic data fit well with a DGP interpretation.

The size and character of the lava pile and observed lava extrusion rates imply a time for emplacement of less than 6,000 years and probably closer to 4,000 years. This includes significant times for exposure of flow surfaces to erosion and soil formation. Weathering profiles, topographic development, and paleosols should therefore mark contacts. The greater the amount of time between flows, the more common and well developed these features should be. Their paucity is difficult to explain even within the biblical time frame, and virtually impossible within the EGP.

The nonlinear decrease in extrusion implied by Iceland's structure has implications for plate tectonics theories. Long-term uniformity in both extrusion and relative plate motion rates would not have generated the observed structure. Stochastic extension or plate motions decreasing less rapidly than lava extrusion could fit the geologic data. Such plate motions would be more readily accommodated by CPT, though nonuniform extrusion could be accommodated by the local interaction of the rift and mantle plume (especially with infinitely flexible plume theories). Existing rift transect survey data do not show expected plate motions. The geologic structure and transect data can be easily explained without plate tectonics, which also offers no apparent solution to the dearth of unconformities and other time indicators between flows.

Conclusions

The geology of Iceland indicates the rapid formation of its lava pile. Evidence of significant time between lava flows is lacking. Extrusion rates observed at historic eruptions provide a basis for concluding that Iceland formed in postdiluvian time within the biblical timescale. The geology of Iceland does not support deep time nor does it offer unambiguous support to plate tectonics.

Appendix A: Volcanology Primer

Igneous rocks solidify from a melt or partial melt. They are either plutonic (intrusive) or volcanic (extrusive), and rock texture usually differs between the two. Volcanic rocks are generally very fine-grained and sometimes vesicular (filled with tiny tubes formed by gases exsolving from lava). Igneous rocks can also be broadly classified by chemical composition:

- sialic: rocks rich in silica and alumina (e.g. rhyolite)
- mafic: rocks rich in magnesium and iron (e.g. basalt)
- intermediate: calc-alkaline rocks (e.g. andesite)

Igneous petrology is, of course, far more complex. A variety of minerals combine to form a plethora of igneous rock types. However, for the non-geologist, the simple classification provided here may prove useful.

The chemical composition of magma (molten rock beneath the earth's surface) strongly affects the type of eruption. Volcanic eruptions can produce tephra (material ejected into the atmosphere) and lava (molten rock that flows onto the earth's surface). Contrary to popular misconception, lavas are commonly extruded as mixtures of crystals and melt, not as a simple liquid, and thus porphyrtic lavas are not uncommon. A porphyry is a rock consisting of relatively large crystals (phenocrysts) embedded in a fine-grained matrix (groundmass).

Sialic lavas tend to be very viscous, squeezing out of vents like thick toothpaste. They tend to produce small, steep-sided domes, like that formed inside the crater of Mount St. Helens, Washington, after the 1980 eruption. Rhyolite flows are documented in the rock record, but the conditions required to form them apparently do not exist in the present. "Although very siliceous lavas are not uncommon in the geological record, no eruption of rhyolitic lava has been observed by a geologist" (Bardintzeff and McBirney, 2000, p. 81). Extensive flows must have been erupted at temperatures above or near their liquidus (completely molten), causing some geologists to conclude that rhyolite flows are rheoignimbrites, a special kind of welded tephra deposit (Peate, 1997). They may indicate the special conditions prevailing during the Deluge.

Mafic magmas tend to reach the surface in relatively quiet eruptions with relatively large amounts of lava. The earth's crust is dominated by mafic rocks. Oceanic crust consists largely of basalt. Mafic volcanoes are typically large and form shield volcanoes, with very gentle, broad slopes. The Hawaiian Islands are shield volcanoes. Basalt can often erupt from fissures, and the largest volume and highest flow rates are from fissures. Fissures typically shrink and become isolated as conduits as lava extrusion decreases and various points along the fissure erode into larger openings. Extensive basalt flows characterize the mid-ocean ridges of the North and South Atlantic Oceans and the Pacific "ring of fire." One of the most remarkable of volcanic phenomenon is large igneous provinces in which flood basalts cover entire regions, notably in the northwestern United States, Siberia, and India (Table I).

Intermediate magmas produce explosive eruptions with large amounts of tephra. They produce volcanoes with intermediate properties, typically stratovolcanoes. Examples include Mount Fujiyama and Mount St. Helens. They tend to form along continental margins, and andesite was long thought to represent melt from subducted lithosphere, though this is now a discredited concept (see McBirney, 1993, pp. 315–316).

Rates of lava extrusion are governed by many variables, including vent size and geometry, composition of the magma, temperature of the lava, volatile content, and the eruptive environment. Marine eruptions below a depth of 4 to 5 km (15,000 ft.) retain their volatiles due to pressure (Froede, 2000; also see Barndintzeff and McBirney, 2000, p. 148). A crust often forms on the top of a flow due to cooling by air or water, insulating the lava beneath and enabling it to continue to flow for considerable distances. Often the movement is concentrated in conduits in the lava flow, which may later drain to form caves called lava tubes. This is typical of pahoehoe, generally a fluid, volatile-rich basalt that produces a ropey surface texture (Figure 9). Basalt often also produces a'a, a form

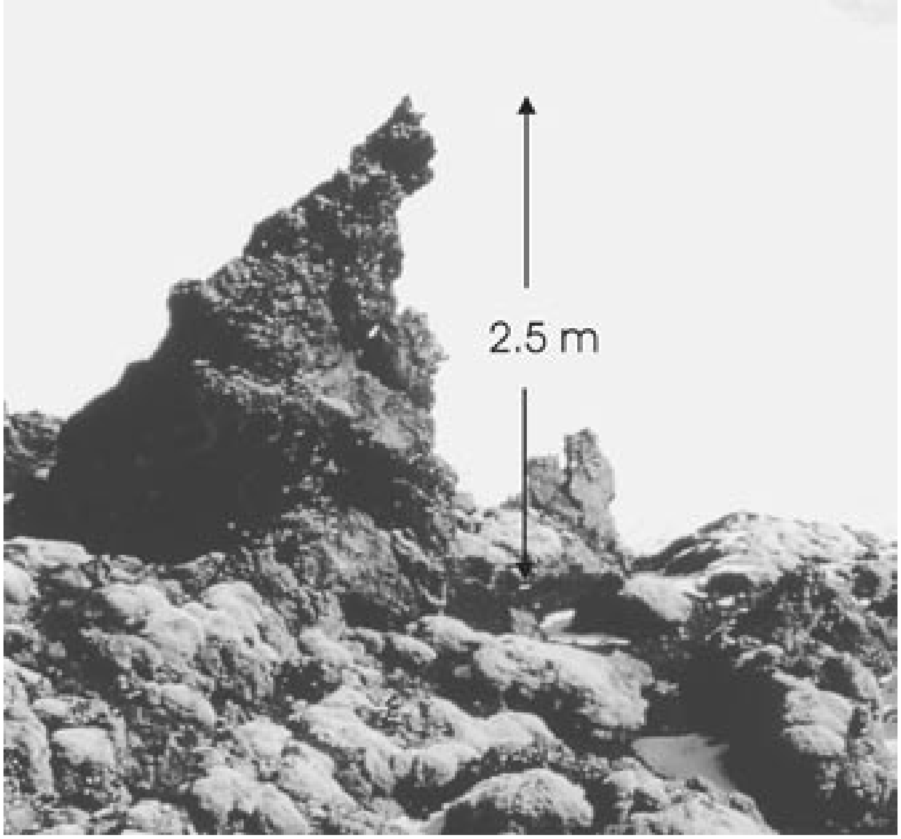


Figure 24. A'a basalt is typified by rough, jagged surfaces such as that evident on the edge of the 1947 block flow on the southwest side of Hekla.

with a very rough surface texture resulting from shearing and loss of volatiles (Figure 24). Block flows are intermediate between pahoehoe and a'a.

The emplacement environment can be partially inferred from field characteristics (Table V). Some of the characteristics formerly thought diagnostic of a subaerial environment are now known to form in a subaqueous environment (Froede, 2000).

Table V. Diagnostic Features of Lava Flows

Feature	Interpretation
Vesicles	Significant volatile content in lava which exsolved. Higher volatile content results in lower melting temperature and lower viscosity.
Phenocrysts	Lava was only partially molten. Phenocrysts may provide information useful to inferring parent composition, country rock, or other features.
A'a, blocks, pahoehoe	A'a is evidence for rapid emplacement with high shear and high loss of volatiles. Pahoehoe is evidence for low viscosity. Block flows are intermediate.
Columns	Columns indicate cooling within a single flow and the direction of the thermal gradient.
Pillows	Pillows are indicative of subaqueous emplacement.
Palagonite	Palagonite indicates quenching of lava by water or ice.
Tuff	Tuff is pyroclastic. Welded tuffs are fairly common and are typically believed to form subaerially, though subaqueous emplacement of a welded tuff is possible.
Interbeds	Interbeds of sedimentary or volcanisedimentary rocks between lava flows indicate existence of sedimentary processes between discrete volcanic events or contemporary with them.
Tuyas ("table mountains")	Generally believed to result from subglacial eruptions.

Appendix B: Estimating Time Required for Lava Emplacement

Data used for estimating maximum times required for emplacement of the lava in Iceland are shown in Tables II and VI. Assumptions used in the calculations are listed in Table VI. Volume was estimated by integrating a vertical, truncated cone with the properties listed in Table VI. I made the conservative assumption that 35 percent of the total extruded volume was lost to the sea and atmosphere.

Based on observations and geologic maps, I estimated the percentages of three types of flows: (1) flood basalts, (2) modern (generally block) flows, and (3) an "intermediate zone" with intermediate properties (and presumably flow rates). The crust beneath Iceland is complex (Du and Foulger, 2001), and precision greater than the assumptions in Table VI was not possible in this study. I made the conservative assumption that only a single fissure (initially the Mid-Atlantic Ridge) supplied all of the lava, and that the active length of this fissure declined over time. By contrast, in historic times, *en echelon* fissure systems have often been observed, and some estimate that the extrusion rate in Iceland has been twice that of the Mid-Atlantic Ridge elsewhere (Sæmundsson, 1980).

Flow rate values were derived from the data in Table II. Although the Lakagígar flows were block flows, not flood basalts, I deemed the estimated initial Laki extrusion rate to be an appropriate minimum flood basalt flow value. Icelandic flood basalts consist of overlapping shields cut by dikes that compose up to 20 percent of the rock (Walker, 2000, p. 288), so Lakagígar is a good analog. The maximum flood basalt rate is that estimated for the CRBG (Shaw and Swenson, 1970). While this estimate for turbulent emplacement of the CRBG has been criticized for assuming Newtonian fluid dynamics (Self et al., 1997), it is probably valid at the vent (Tallarico and Dragoni, 2000), though less so elsewhere (Baloga et al., 2001). Self et al. (1997) suggested a decade or more for emplacement of major CRBG flows, but Oard (1999) presented evidence for more rapid emplacement. The minimum unit extrusion rate for Iceland's modern volcanic zones is an average of the minima from the 1970 eruption of Hekla, five eruptions of Krafla between 1980 and 1984, and the 1973 eruption of Eldfell on the island of Heimaey. The maximum value for the modern volcanic zones is the upper limit of the eight-month average for Lakagígar, though this value was equaled by the 1970 eruption of Hekla and exceeded by the 1980 eruption of that volcano. The values I used for intermediate zones were the minimum Lakagígar eight-month average and maximum Lakagígar initial discharge estimate. Although the October 1980 eruption of Krafla produced a higher unit extrusion rate, the larger scale of the Laki eruption probably makes it a better analog for large events of the past. This also provides a slightly more conservative approach.

Self et al. (1997), in their effort to rein in catastrophic interpretations of the CRBG, assert that the Laki maximum unit extrusion rate approximates the average Roza flow extrusion rate in the CRBG. Others have followed suit (e.g. Rothery, 2001). If these uniformitarians look to Lakagígar to reign in catastrophic interpretations of flood basalt extrusion rates, this seems to confirm that the rates used in this study are conservative and give uniformitarians the benefit of the doubt.

It is important to note that these estimates assume that during nearly all of Iceland's history, only part of the country was experiencing emplacement of lava. Even during emplacement of flood basalts, I have assumed that individual flows were extruded at the given rates and fissure lengths presented above. This may be an overly conservative assumption, as flood basalts may well be at least an order of magnitude greater than the historic values (see Sigurdsson, 2000b, p. 276). Also, many of the flows, especially subaqueous flood basalts, probably grew by inflation, meaning that weathering processes were already active during the time the flows were being emplaced.

Table VI. Lava Emplacement Time Parameters

Assumption		Value
Land area of Iceland in square kilometers[1]		103,000
Assume 35% lost to erosion, resulting area in square kilometers		158,462
Equivalent radius assuming circular land mass, in meters		224,588
Height above sea floor in meters[2]		4,000
Average slope ratio to sea floor (horizontal:vertical)[2]		62.5:1
Maximum fissure length (single fissure through diameter) in km		949
Percentage of total pile that is flood basalt		75
Percentage of total pile represented by modern volcanic zones		10
Percentage of total pile that is intermediate between above zones		15
Maximum and minimum effective fissure lengths as percentage of maximum fissure length	Flood basalts	40–100
	Modern volcanic zones	5–10
	Intermediate zones	10–40
Flow rates in m^3/s per m of fissure length▼		▼Basis for estimate
Flood basalts	0.60–12.00	Lakagígur initial maximum to CRBG maximum[3]
Modern volcanic zones	0.01–0.03	Hekla-Eldfell-Krafla average min. to Lakí avg.[3]
Intermediate zones	0.02–0.60	Lakagígur avg. min. to Lakagígur initial max.[3]
Total estimated volume of lava pile in cubic kilometers		1,601,000

[1] Bridgwater, 1960, p. 622; Sigurjónsson and Tilnius, 1994, p. 133.
[2] Foulger et al., 2000, p. F1.
[3] See Table II.

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Glossary

aeolian: said of processes or sediments involving transport by wind.

dacite: a felsic, sub-alkaline (intermediate) rock containing at least ten percent quartz.

en echelon: parallel features offset diagonally.

hornito: a typically small (one to several meters) structure resembling a stratovolcano and formed by steam escaping through lava that has flowed over water or wet ground.

hot spot: generally believed to be a fixed, narrow, cylindrical plume of especially hot magma originating deep within the mantle.

hyaloclastite: coarse volcanic rock formed from quenched lava.

ignimbrite: fragmental, pyroclastic rock.

Landnám: the period beginning in A.D. 870 and extending to ca. A.D. 930 during which Iceland was permanently settled; it marks the beginning of its recorded history.

loess: open-structured silt, typically formed by aeolian deposition.

palagonite: yellowish-brown altered volcanic glass formed from quenched basalt.

paleosol: a "fossil soil profile," i.e. a soil profile preserved beneath the zone of modern soil formation.

pedogenesis: the processes of soil formation as determined by the five environmental factors mediated by the four soil-forming mechanisms (Klevberg and Bandy, 2003a; 2003b).

rheoignimbrite: an ignimbrite emplaced at high temperature, facilitating flow prior to freezing (i.e. lithification).

stratovolcano: a form of volcano composed of alternating pyroclastic and lava strata, typical of intermediate lithologies. Examples include Fujiyama, Mount Kilimanjaro, and Mount Rainier.

stochastic: said of a continuous function with an unpredictable or random path.

tholeiite: a type of basalt relatively rich in silica and iron and typical of mid-ocean ridges.

tuya: a "table mountain" or steep-sided butte of volcanic origin, characteristic of Iceland, believed to have formed by subglacial eruption.

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CENTJ: *Creation Ex Nihilo Technical Journal*

TJ: *Technical Journal (formerly CENTJ,* now *Journal of Creation)*

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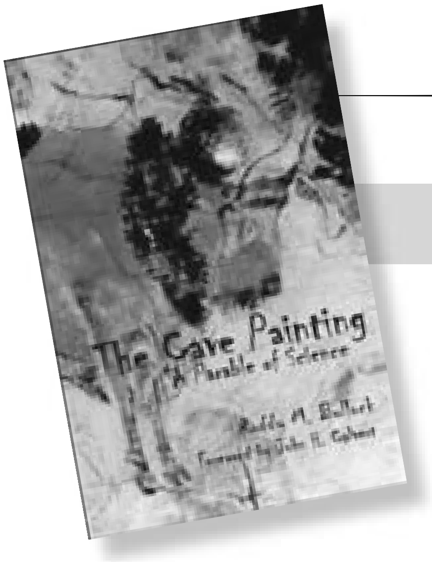

Book Review

The Cave Painting: A Parable of Science

by Roddy M. Bullock

Access Research Network, Colorado Springs, 2007, 450 pages, $16.00.

In this combined work of fiction and nonfiction, Bullock skillfully illustrates by analogy the absurdity of denying design for something that is clearly and obviously designed. A recently discovered painting in a cave showing no evidence of human entry or occupation sets up this fascinating novel. With no evidence of human origin, and with mixed motives for doing so, scientists theorize the "apparent painting" is a product of purely natural forces of nature. Denying what logically appears to be a painting completed by intelligent beings, and trying to argue it came into being by natural forces, is exactly analogous to what Darwinists are trying to achieve. Bullock's allegorical narrative weaves together in story form all aspects of the evolution/intelligent design (ID) debate, including the religious motivations inherent in the questions, as well as the larger cultural and ethical issues presented by purely naturalistic worldviews.

The story line of the novel is engaging and informative, but it is not the most important part of the book. About half of the book (pages 1-229) is fictional, but the remaining portion of the book (to page 439) contains nonfiction explanatory endnotes, by far the more valuable part of the book. In the endnotes Bullock provides detailed explanation and analysis of the issues, as well as documented support for the views expressed by analogy in the novel. The documentation section is one of the best reviews this reviewer has read on the contemporary conundrum created by the dogmatic insistence that things that clearly look designed are not. The book invites the reader to carefully consider the question, "Is design real or is it an illusion?"

Obviously, arguments exist on both sides of the "design versus no design" question, and this is the author's main point. But Bullock brings clarity to the debate by stressing throughout the logical implications of the logical law of noncontradiction. As stated on one of the front pages, "We either *are* the product of intelligent design, or we *are not* the product of intelligent design. One of the above statements must be true. Truth is not changed by your theory or mine." While being fair with the issues, Bullock, a creationist, never loses focus of the truth.

Using human-made objects as examples, Bullock stresses the logically necessary point that the natural world is likewise either designed or not designed.

If the universe was not designed but has only the appearance of design, then design is not objectively real, but an illusion. There is no middle position, and the question of design versus no design is a *scientific* question, not religious. Presumptively categorizing the "design" hypothesis as "religious" and the "not designed" hypothesis as "scientific" commits both the fallacy of mislabeling and begging the question. Bullock argues persuasively that to conclude *a priori* that design in the natural world is not scientifically testable is both illogical and inconsistent.

To support his point that design detection is a routine scientific activity, Bullock discusses several actual examples of scientists engaged in determining intelligent design. For example, a rock recently found in North Carolina said to be 50,000 years old showed signs of having been formed as a tool (Endnote 1, page 232). Competing groups of scientists questioned whether the rock shape was due to human manufacture or natural processes because if designed as a tool it challenges the current scientific belief that the earliest period of human inhabitation in North America was 13,000 years ago.

Another example Bullock discusses is the famous photo taken by NASA's Viking 1 spacecraft that reveals a landscape pattern on Mars revealing a striking resemblance to a human face. This photograph alone convinced many people that intelligence must have created the object. Further research, though, convincingly showed that the rock formation is not intelligently designed. Nevertheless, this and other examples show that scientists can, and do, engage in the science of design detection.

Bullock stresses that definitions are critical when discussing this topic. In harmony with his advice, he carefully defines many of the key terms commonly used in the debate. Bullock then notes that many Darwinists intentionally use the term "evolution" without defining it to allow them to utilize evidence of small changes in features of living organisms (microevolution) as proof of the unguided, purposeless creation of new features (macroevolution). He notes, for example, that the term "evolution" is so malleable in the literature that it can be hammered out to mean everything from biological change over time, such as seen in children compared to their parents, to "molecules to man" evolution (p. 237).

Another definition Bullock tackles is that of science itself. He shows that science can be defined in such a way to show intelligent design is not science; but when defined objectively, intelligent design clearly is science. An objective, presumption-free definition is important if science is to remain tentative and evidence based. Those opposing intelligent design define science non-objectively as requiring only non-intelligent, random causal explanations, thereby rendering intelligent design unscientific by definition, regardless of the evidence.

Bullock also evaluates many common criticisms of both ID and creation. As one example, he quotes a Darwinist who states that anti-evolutionists (which the Darwinist called "propagandists") are "always religiously motivated, even if they buy creditability by concealing that fact" (p. 243). As Bullock notes, in the end the key is whether the arguments are true or false, not motives. Historically, Darwin and many of his followers had strong motives to come up with a theory of origins that excluded a creator. Thus, theism may motivate some people and atheism motivates others, but a scientific hypothesis should be evaluated on its merits, regardless of motives. Moreover, the claim that intelligent design theorists are religiously motivated is often not true. Many people who accept intelligent design were once atheists and their motives were anything but religious.

Space limits reviewing the other excellent material in this work, but the examples provided should give the reader a flavor for the arguments utilized. For those new to the debate, including students, the novel will be fun and informative. For everyone, including people who are familiar with the basic issues, the second half of the book is highly beneficial. The author is clearly well read, citing a wide variety of literature, that written by supporters as well as by detractors.

Bullock's extremely well-written book is complete with an index and is documented with almost 700 notes. It also avoids many of the problems common in books of this genre. An example is overgeneralization, making statements that are ambiguous or, true in general, but need to be carefully qualified in order to be accurate. I noted no mistakes or even any areas that I felt could be significantly improved. The conversational writing style is engaging and highly informative. The tone is one of respect for both sides, stressing understanding and insight into the basic controversy. The nonconfrontational writing helps the reader to reason about the issues covered. My only suggestion would be to publish the second part of the book separately.

In short, this book is an excellent summary of a controversy that shows no signs of abating. Even those who disagree with the thesis of this book must come to grips with the arguments it presents. The work is highly recommended and I predict will become an important source for both creationists and intelligent design theorists. Many issues that can be distractions, such as the age of the earth or scriptural and biblical topics, are not mentioned. The text is ideal for students, including homeschoolers and study groups, yet is fully appropriate for a secular market as well.

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Notes from the Panorama of Science

Self-Warming Skunk Cabbage

Introduction

Endothermic birds and mammals have the ability to maintain a high and stable body temperature during wide variations of environmental temperature. The tender flower cluster (spadix) of skunk cabbage cannot withstand freezing temperatures, yet it emerges early in spring as temperatures still drop below freezing and snow remains on the ground. Skunk cabbage has the ability to elevate the temperature of the spadix as much as 25 degrees C (77 degrees F) above the environmental temperature. This provides protection against freezing and even melts the surrounding snow. This metabolic heating is accomplished by using vast stores of energy from the huge underground rootstock. It is difficult to imagine how such a sophisticated and metabolically costly physiological trait, reminiscent of the non-shivering thermogenesis found in endothermic vertebrate animals, could have arisen by random variation in the skunk cabbage.

A fact not widely known even in the scientific community is that several plants can produce significant amounts of metabolic heat resulting in the elevation of the tissue temperature. These include the common *Philodendron* (Seymour et. al., 1983), the sacred lotus, *Nelumbo nucifera* (Seymour and Schultze-Motel, 1996), as well as the widely distributed skunk cabbage. The western skunk cabbage, *Lysichitum americanum* (Figure 1), is an unmistakable harbinger of spring, often making its appearance before winter's snow has gone (Craighead et al, 1963). The common name comes from the observation that the crushed leaves smell mildly like the defensive odor of a striped skunk, *Mephitis mephitis*, but its odor is less offensive than the more widely distributed eastern skunk cabbage. The western species of skunk cabbage also is sometimes known as the "swamp lantern," because of the way its bright yellow fluorescent flower stands out on the drab forest floor in swampy areas.

Lysichitum is a genus of only two species, the other being *L. camtschatcensis*, which has a white spathe and is native to northeast Asia. The plant referred to as eastern skunk cabbage, *Symplocarpus foetidus* (Figure 2), has a somewhat similar appearance, but it has a purplish or mottled brownish spathe. Both *S. foetidus* and Lystichitlissare are members of the Araceae (lily family).

The western skunk cabbage is found from Alaska south to northern California, and east (but less common) to Montana and Idaho. It is most common west

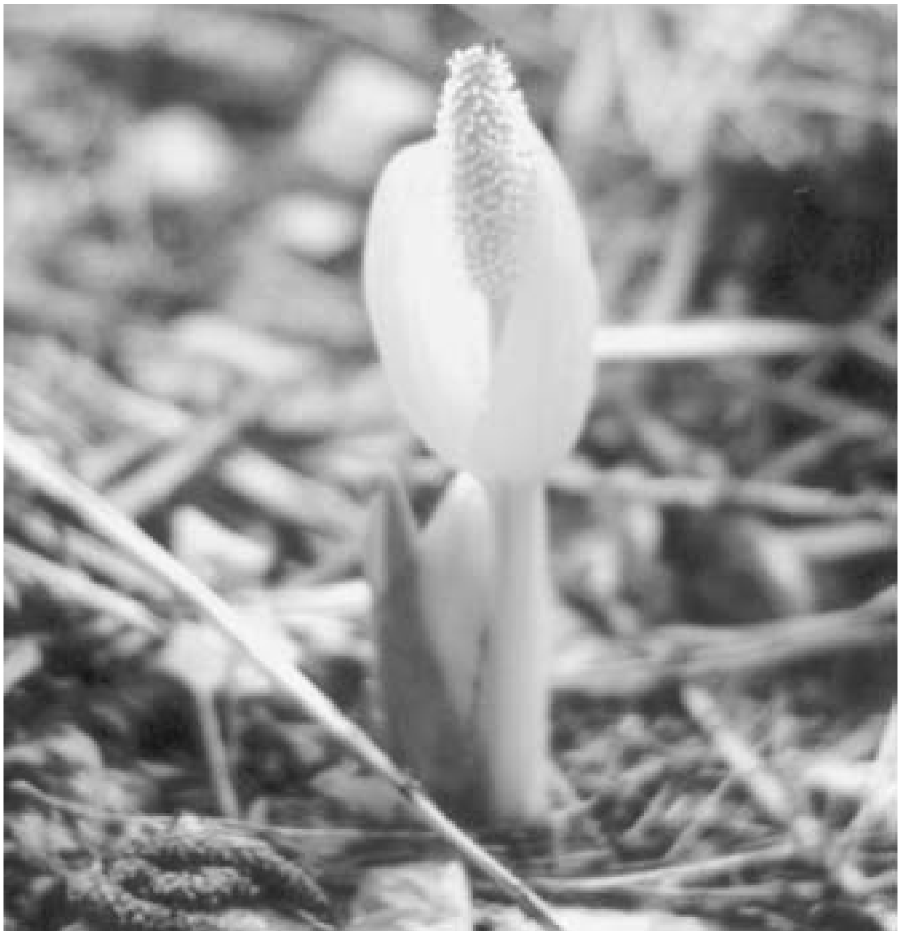

Figure 1. Western skunk cabbage, *Lysichitum americanum*. Photo by E. N. Smith near Snoqualmie Pass, Washington State.

of the Cascades, but is plentiful in wet areas inland. This plant grows in swampy regions and is generally found in the wet ground under or near cedar trees. It is sometimes a dominant understory plant of cedar/alder communities, especially in locations that support western red cedar (*Thuja plicata*).

It is considered edible (Kirk, 1975). In the past, Native Americans roasted and dried skunk cabbage and then made flour from its starch. It is believed that they used mainly the rootstalks and young leaves. Several references report that it was only a "famine food," however, and not a staple of their diet. Some tribes reportedly used skunk cabbage leaves as "Indian tinfoil," and lined berry baskets and steaming pits with them. The plant (and many other members of the Arum family) contains crystals of calcium oxalate, which sting and burn the lips and mouth if eaten raw. To be edible, the toxic leaves must be dried, pulverized, and cooked, breaking down the crystals (Pojar and MacKinnon, 1994).

Thermoregulation in Animals

In order to appreciate the remarkable physiological feature of skunk cabbage, one first needs to know how some vertebrates regulate their body temperature. All biochemical reactions are profoundly influenced by temperature. Rates of biochemical reactions increase with higher temperatures and slow down as the temperature drops. Animals have two contrasting methods of regulating their body temperature. Warm-blooded, or endothermic, vertebrates, including mammals and birds, maintain a high and constant body temperature by a combination of behavioral and physiological methods. Behaviorally, they avoid temperature extremes when possible. For example, many mammals seek shade when hot. When warm, they increase blood flow to the skin, releasing body heat to the environment. If the body temperature continues to increase, many animals sweat or pant, and the resulting evaporation of water cools the animal. When cold, blood flow to the periphery is reduced, thereby reducing loss of body heat to the environment. The skin then acts as a thermal insulator. If the body temperature continues to drop, shivering may result. These involuntary rhythmic contractions generate heat, thus assuring a constant high body temperature. The cost of such thermoregulation is great, and most animals rely on behavior to control their body temperature. Also, additional heat is produced by non-shivering thermogenesis when cold.

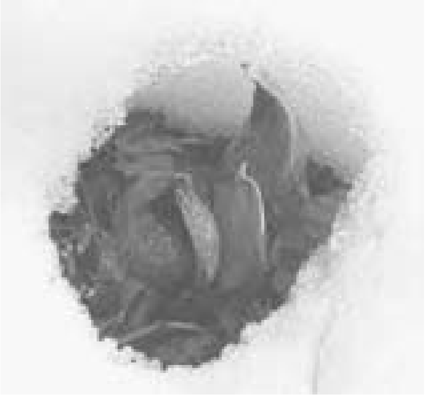

Figure 2. Eastern skunk cabbage, *Symplocarpus foetidus*, melting snow. (Photo copyright owned by Walter Muma and used with permission. Source: http://ontariowildflowers.com/main/species.php?id=105)

Cold-blooded, or ectothermic, animals, in contrast, obtain body heat largely from the environment. If one places a lizard, salamander or fish in a refrigerator overnight, the body temperature approaches that of the refrigerator. Animals normally do not live in a refrigerator; in their natural habitat they often have a mosaic of environmental temperatures available. Reptilian behavioral and physiological thermoregulation was my primary area of research for several years (Smith, 1975a; Smith, 1975b; Smith, 1976a; Smith, 1976b; Smith and Adams 1978; Smith et al.1978; Smith, 1979; Robertson and Smith, 1979; Smith and Adams, 1981; Robertson and Smith, 1981; Davies et al. 1982; Smith et. al., 1984; and Smith et. al., 1986). When cold, ectothermic animals such as lizards bask in the sun to increase their body temperatures. Many align their bodies perpendicular to the sun, maximizing exposure and heat absorption. When hot, they seek shade or orient directly into the sun, thus reducing the surface area exposed to sunlight. By this simple behavioral thermoregulation, many ectothermic animals maintain relatively high and stable body temperatures at much less energy cost than their endothermic counterparts.

Animal thermoregulation is complex, and the boundaries separating the two kinds of thermoregulation are sometimes unclear. Various intergrades between ectotherm and endotherm exist. For example, hibernating endothermic mammals become ectothermic during hibernation and allow their body temperature to drop in order to save energy during winter. The swimming muscles of some large ectothermic fish, such as tuna, are essentially endothermic, while the temperature of the rest of the body approximates that of the environment. Some large female snakes generate body heat while incubating their eggs. Even the flight muscles of bumblebees and certain other insects are regulated far above the environmental temperatures, enabling more efficient contraction. Other complex intergrades are described in the literature.

Endothermic Skunk Cabbage

The skunk cabbage is one of those complex intergrades in thermoregulation. Most of the time, its temperature approximates that of the environment, as in other plants. In early spring, however, it can become endothermic and generate enough heat to avoid freezing. The tightly packed club-like shoot or spadix emerges through the soil very early, when freezing temperatures often occur.

Unlike other cold-hardy plants, it is not "freeze hardened." If the spadix tissue freezes, it is destroyed. As the environmental temperatures drop, the tiny spadix actually generates enough metabolic heat to avoid freezing. It literally melts the snow around it by heat generated from stored food in the rootstock.

Metabolic studies show another unusual characteristic. The lower the environmental temperature, the greater the amount of metabolic heat produced by the skunk cabbage. This plant is physiologically similar to endothermic animals. When the environmental temperature drops to freezing, or 0 degrees Celsius, the spadix temperature can be maintained at 25 degrees Celsius, or 45 degrees Fahrenheit (Knutson, 1972). Most astounding is the fact that the actual rate of metabolism of this plant approaches that of the high metabolic rate of a tiny shrew, or even that of the flight muscles of a hummingbird during hovering flight. Certain aspects of the control and thermoregulatory dynamics have been further elucidated (Ito and Ito, 2005).

Evolutionist's Nightmare

The high rate of metabolism of small birds and mammals is well known. The observation that an isolated group of plants can achieve the same extraordinarily high rate of metabolism as mammals and birds is not only remarkable but also a true nightmare for evolutionists. In order to accomplish this amazing feat, many things must be available and functional at the same time. For example, the plant must have a huge store of accessible energy. Without it, such heating would deplete the reserve and the plant would die. It must have the equivalent of temperature sensors to detect near-freezing temperatures and a complete system to reverse the normal reduction of metabolism as the temperature decreases. Evolutionists have no tenable explanation for these remarkable physiological traits.

"You are worthy, our Lord and God, to receive glory and honor and power, for you created all things, and by your will they were created and have their being" (Rev 4:11 NIV).

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Notes from the Panorama of Science

The Catastrophe at Sodom and Gomorrah

The Bible draws attention to geographic, geologic, and climatological changes caused by the destruction of Sodom and Gomorrah. It specifically describes the landscape of the Jordan plain and of Egypt before God destroyed the cities.

> And Lot lifted up his eyes, and beheld all the plain of Jordan, that it *was* well watered every where, before the LORD destroyed Sodom and Gomorrah, *even* as the garden of the LORD, like the land of Egypt, as thou comest unto Zoar (Gen. 13:10 KJV).

Morris (1976) and Wiseman (1977) argued that this portion of Scripture was written by eyewitnesses soon after the events. The large herds of both Lot and Abraham also suggest an environment different from today's desert.

It seems that the salt sea was not present when Lot chose to live on the plain. And later when the plain's five kings fought four kings there (Gen. 14:8–10), the sea still does not enter the story. In the Genesis 14:3 reference, "in the vale of Siddim, which is the salt sea," the second phrase appears to be an editorial insertion, linking the original name, Siddim, which means "field" or "plain," to the salt sea name known at the time of Moses. Similar insertions occur at least ten times, such as in Genesis 48:7, which links the old name, Ephrath, with the newer name of Bethlehem. The sea does not enter the original story in any way—not when Lot chose the land, not when a battle was fought there, and not when Abraham looked down upon the smoking plain the morning after the catastrophe.

The salt sea is mentioned later in Moses' time when God described the boundaries of the land (Num. 34:3), when Joshua crossed the Jordan River (Josh. 3:16), and again when Joshua specified the borders for Judah (Josh. 15:2, 5). In nine references, it is sometimes called "the sea of the plain, the salt sea."

From the Bible, then, it appears that both the Jordan plain and Egypt were fertile prior to the destruction of Sodom and Gomorrah, that the salt sea was not present, and that within a few centuries, descriptions noted the presence of the sea.

The Great Rift

The Dead Sea is about 1,300 feet below sea level, the lowest water surface in the world. It lies within the Great Rift that stretches over 4,000 miles from Syria to near the southern tip of Africa, the longest rift in the world (Figure 1). The Dead Sea portion of the rift is a graben, bounded by parallel faults moving in a left-lateral transform of several kilometers, based on gravity, magnetic, and seismic data (ten Brink et al., 1999; Fleischer, 1995; Rybakov and Fleisher, 2003). Seismic imaging (Maercklin et

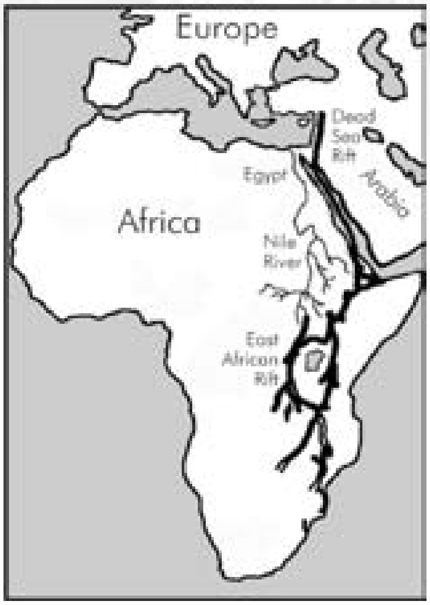


Figure 1. The Great Rift extends over 4,000 miles from southern Africa into Syria.

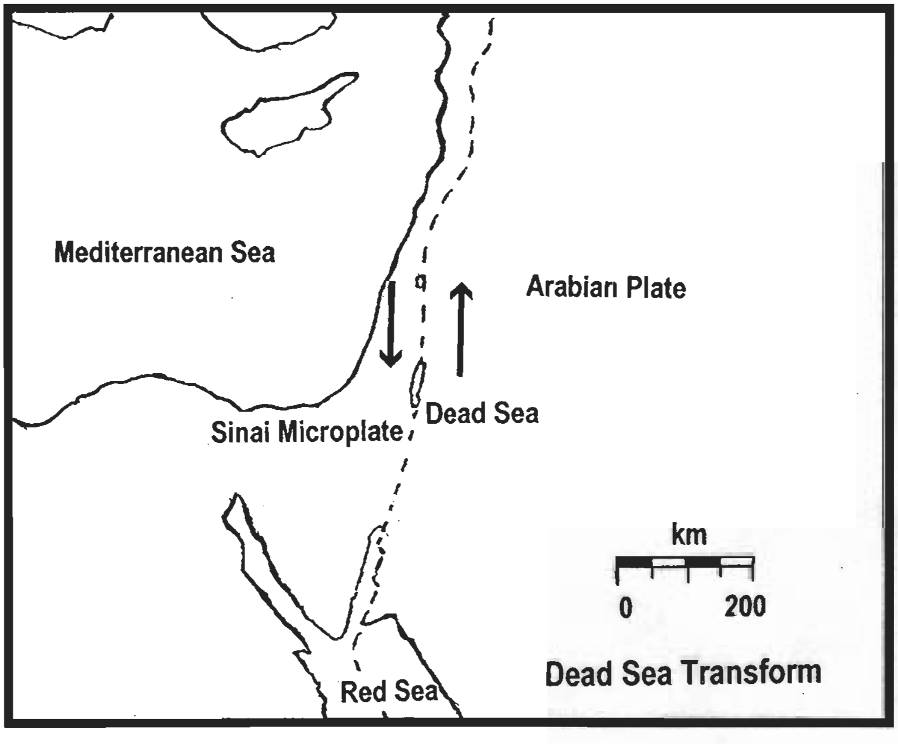


Figure 2. Diagram of the Dead Sea Transform, according to the plate tectonic theory.

al., 2004) is shown in Figure 2. This offset formed rhomb-shaped sub-grabens in the valley floor (e.g., the Sea of Galilee). The left-lateral offset does not continue south through Africa. However, features such as uneroded scarps point to a rapid, recent formation for the rift.

In northern Africa, deserts now border the rift to both east and west. Good evidence in both areas show that these regions were not always deserts. Arabia is an ancient massif that tilted eastward, so that the western and southern edges, next to the rift, tilt upward. The central Arabian plateau is marked by a number of dry riverbeds that trend eastward from the Red Sea escarpment toward the Persian Gulf. In northern Arabia the most significant feature is the Wadi as Sirhan, a large basin that is the vestige of an ancient inland sea. The Sahara on the west also shows evidence of dramatic climatological changes. Archaeologists have uncovered tools and other artifacts that indicate a history of farming and grazing, as well as over 30,000 petroglyphs of farm animals and aquatic animals such as crocodiles. Remote imaging also reveals a former wetter landscape beneath the sands (Fowler, 2000).

Some scientists propose that various kinds of astral events, including impacts and near misses of heavenly bodies, were associated with geological, geographic, and climatological earth changes. Warmkessel has collected more than 230 such scientific studies (Warmkessel, 2005). He correlates astral events with periods of increased atmospheric dust, volcanic activity, varied solar activity, and abrupt climate changes. Some studies there discuss how impacts have triggered catastrophic lava flows, established new plate boundaries (Alt et al., 1990), and repeatedly disrupted civilizations. For instance, ice cores from Mount Kilimanjaro show when the tropical glaciers began forming, and three periods of abrupt climate change, one coincident with the period of the greatest drought in tropical Africa.

An Early Bronze-Age Catastrophe?

The Early Bronze Age (EBA) city of Ur suffered sudden destruction, according to archaeologists and ancient documents. "The Lamentation of Ur" (Jacobsen, 1978) includes the following:

> Enlil called the storm. He called disastrous winds.
> The hurricane devours the city's ships.
> Great fires he lit that heralded the storm.
> Its corpses, not potsherds, piled on the roads.

Similar documents, "The Curse of Egypt" (Niroma, 1996) and "The Curse of Agade (Akkad)" (Cooper, 1983), said to have been written about a century after the disaster, describe crop failures and famine.

Archaeologist Kathleen Kenyon (1979), known for her work at Jericho, wrote that every EBA Palestinian town so far investigated ended with catastrophic destruction. Wright (1965) said the destruction was so violent that very little survived. He added that it must have been about the time of the fall of the Old Kingdom of Egypt. The second layer of Troy is classified as EBA and it, too, suffered sudden destruction (Cardogan, 1997), along with other Aegean cities that also lie along regional tectonic trends. From the Bible we know that the destruction of Ur had to have occurred after Abraham emigrated; Sodom and Gomorrah were destroyed soon afterwards.

If all these events were simultaneous, there might have been an astral trigger. But past encounters with comets or asteroids are difficult to study. Timo Niroma of Finland has pulled together information on this from books and articles of several scientists and from a Cambridge conference on the collapse of the first great civilizations, including Egypt. He cited studies from Mesopotamia, Egypt, Troy, Palestine (including Sodom and Gomorrah), the Indus Valley, and even as far as China and the Americas. The population of his native Finland was reduced by two-thirds. He proposes that Earth was hit by a comet that had fragmented, like Comet Shoemaker-Levy 9, which hit Jupiter in 1994. Baillie (2000) studied tree-ring and ice-core dating, listing five potential near misses by comets in the last 5000 years. One of his dates, by his secular dating, is within a few centuries of Abraham, and another might correspond to the Exodus.

History Dating Problems

Geologists and paleontologists explain anomalies in their presumed order of layers by citing overthrusts or erosion to maintain the integrity of their model. Archaeologists operate in a similar fashion. Dates of artifacts often change to suit new models. Everybody expects small problems to work out. But some contemporary historians believe that the base of all this dating, the Egyptian chronology, is too long by several centuries. Isaac Newton warned of an expanded Egyptian history, and since the early 1900s the chronology of pharaohs developed by Sir William Petrie has formed the basis for historical correlation by archaeologists and others working in the Mediterranean and Middle East. The resulting interconnected labyrinth can only be straightened out with a fresh start.

James et al. (1993) integrated archaeological findings of the past century without referring to Egypt, shortening accepted history by several centuries. Another approach is to use the Bible as an anchor, trying to match history events with it. Stewart (1999) and Rohl (1995) reworked Egyptian history to match the Bible, while Jones (1999) solved many biblical chronological puzzles. All these advocate a compressed time frame. While these historians disagree on how to rearrange the pharaohs, on which pharaohs dealt with which Israelite kings, or even on the pharaoh of the Exodus, all agree that Egypt's history must be shortened by several hundred years.

Matching Egypt's History with the Bible

Today there is rising interest in matching ancient history with the Bible. Contrary to common approaches that start outside the Bible, biblical literalists are reversing that procedure by beginning with the Bible and looking for errors in the historical and archeological data. However, conflicting data sources (e.g., carbon dates, Egyptian records, etc.) slow progress. A possible solution to this dilemma would be for scientists to help pinpoint catastrophes such as the destruction of Sodom and Gomorrah and integrate them with the known sequence of events from the biblical record.

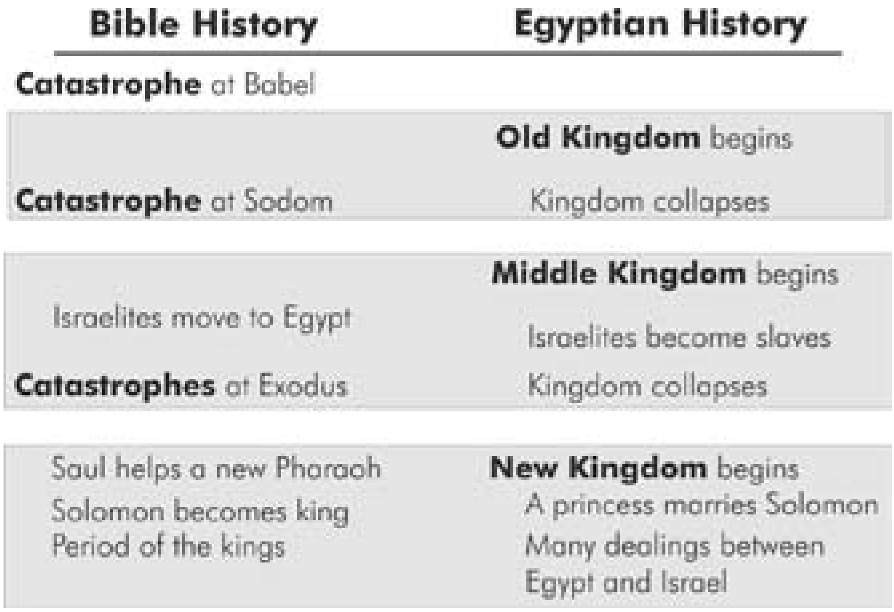
Egypt provides an example of how the biblical approach would proceed. It is clear that Egypt was founded after the tower of Babel, which some people believe was also a catastrophic event. While some pre-Babel explorers could have left campsites that puzzle archaeologists today, the settlers who formed the Old Kingdom of Egypt arrived after Babel. Historians have noted the sudden rise of civilization in Egypt and the similarity of Old Kingdom step pyramids to the ziggurats of Babylon.

Sometime after Babel, Abraham and Lot moved from Ur to Canaan, and later visited Egypt when it was still "like the garden of the Lord." Back in Canaan, Lot chose to live on the Jordan plain, also compared by the Bible to a garden. After God rained brimstone and fire from heaven, the garden landscape drastically changed, becoming the Dead Sea Rift, part of the Great Rift. Thus it does not stretch logic to associate the total rift with this event. If so, this certainly could account for the sudden collapse of the Old Kingdom of Egypt, which most history books characterize as a mystery. Ur, too, fell at some time after Abraham emigrated. If archaeologists are right that a number of other cities fell at the same time as Ur, then all these disasters might be associated with a single violent catastrophe, Sodom and Gomorrah. This happened within a year of Isaac's birth, which was 2108 AM (Anno Mundi, year of the world) according to Bible genealogies.

The next biblical mention of Egypt is Genesis 37:25–28, when Joseph was sold into slavery. This was likely the time of the Middle Kingdom. Later, the Exodus brought the second collapse of Egypt, as at least one historian surmised (Long, 2002), though most historians do not link these events, probably because their dates do not match those from the Bible. Although Exodus says little about earth upheavals, other Scriptures (Judg. 5:4–5; Ps. 114) mention the earth trembling, mountains skipping, and other violence at the time of the Exodus. The destruction of Egypt's crops and cattle, and the loss of their military, their king, and their wealth all point to the collapse of the Middle Kingdom. Events following in the next fifty years indicate further physical upheavals, fire and quaking at Mount Sinai, earth swallowing Korah and his followers, the Jordan River's waters standing in a heap, Jericho's fall, and Joshua's long day.

The Bible tells of a time when Egypt was ruled by Amalekite usurpers. History books confirm a time of chaos and foreign domination after the fall of the Middle Kingdom. They call the usurpers Amu or Hyksos, and their capital was Avaris in Shur, in northeastern Egypt. Egyptians did not harass Israel all through their wilderness wanderings or during the periods of Joshua and the judges, but Amalekites did. Saul helped to destroy the Amalekites (I Sam. 15:1–8), and the next biblical mention of a pharaoh comes when Solomon "made affinity with Pharaoh" (I Kings 3:1) and married his daughter. That probably refers to the New Kingdom, and the Bible relates numerous subsequent interactions between Egypt and the kings of Israel and Judah.

In summary, the Old Kingdom of Egypt was founded after the Babel dispersion and collapsed during the catastrophic destruction of Sodom and Gomorrah. The Middle Kingdom formed prior to Joseph and collapsed at the Exodus. The New Kingdom began about the time that Israel became a kingdom. Egypt is an important nation in the Old Testament, and the catastrophes recorded in the Bible could help to date its major events (Figure 3).



Bible History	Egyptian History
Catastrophe at Babel	
	Old Kingdom begins
Catastrophe at Sodom	Kingdom collapses
	Middle Kingdom begins
Israelites move to Egypt	
	Israelites become slaves
Catastrophes at Exodus	Kingdom collapses
Saul helps a new Pharaoh	**New Kingdom** begins
Solomon becomes king	A princess marries Solomon
Period of the kings	Many dealings between Egypt and Israel

Figure 3. Chart showing proposed correlation of Bible history and Egyptian history.

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A Fossil Insect that Is Too Advanced for its Devonian Date

There has been what could be called a "rediscovery" of a fossil that was found first in the early part of the twentieth century. Originally it was not fully recognized for what it is now seen to be. It is a fossil of *Ryniognath hirsti*, an insect whose age, on the evolutionary dating scale, is 400 million years. This puts it at the start of the so-called Devonian period, and its ancestral line would have gone back well into the preceding Silurian times.

Although thought to be ancient, this insect is by no means primitive. It had all the hallmarks of a true insect. Its jaw parts were such that it was able to chew food with efficient, scissor-like mouthparts called mandibles, each having two joints (Muir, 2004, p. 9). Every other insect having this type of jaw also can fly. This indicates with a high degree of certainty that this fossil insect also was able to fly. Wings are not present on the fossil, but this is probably because the hot springs environment in which it was fossilized is not conducive to preserving wings.

According to evolutionary dating, this creature would have been flying for over 80 million years before the first insect wings were otherwise known. Having a creature this advanced for such a long period of time challenges the accuracy of evolutionary schemes and time frames.

The evolutionists will likely try to make *R. hirsti* fit with evolutionism, but this is not the order in which the evolution of insects would have occurred. Therefore, no amount of rationalization will make these data fit with the standard evolutionary picture. Creation of insect forms is a better origins scenario.

Acknowledgments

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Letters to the Editor

The policy of the editorial staff of CRSQ is to allow letters to the editor to express a variety of views. As such, the content of all letters is solely the opinion of the author, and does not necessarily reflect the opinion of the CRSQ editorial staff or the Creation Research Society.

Questions about the Biblical Age of the Fruitland Formation Coal Beds

Recently, Doughty (2006) published an interesting article addressing the presence of carbon-14 (^{14}C) in Cretaceous-age coal beds from the Fruitland Formation in northwestern New Mexico. He determined that the percentage of ^{14}C present in the coal was consistent with earlier results reported by Baumgardner et al. (2003). This is important work demonstrating that the presence of ^{14}C in the carbon dioxide and methane gases derived from the coal beds provides empirical evidence that contradicts the millions of years used in defining the uniformitarian worldview of Earth history. I eagerly await the promised article on the ^{14}C analysis from Ordovician strata in the Permian Basin of west Texas.

Doughty (2006) presents an excellent study, but I question one part of his conclusions where he states:

> Finally, the evidence presented in this paper strongly suggests that both gases had a common source (coal) thousands—not millions—of years ago, that was laid down in the *aftermath* (Cretaceous period [sic]) of the Genesis Flood. (p. 109; italics added)

If I read this correctly, then the gas-producing coal layer was deposited following the Flood. Is my understanding accurate?

The only evidence that appears to support this position comes from the limited freshwater mixing along the periphery of the coal bed. The freshwater would be derived from post-Flood precipitation.

However, I believe that a greater weight of evidence can be made for the Fruitland Formation and its overlying strata having been formed during the Genesis Flood.

A. The coal gas play occurs approximately 2700 feet below the ground surface.
B. The coal layer is buried by water-transported sediments.
C. The area in which this coal occurs is in the San Juan Basin located in northwestern New Mexico, which is adjacent to the southern portion of the Rocky Mountains. Many young-earth geoscientists believe that the uplift of the Rockies was initiated during the later stages of the Flood, and the development of the San Juan Basin would also coincide with this timing.

I believe that the uniformitarian non-marine interpretation placed on the Fruitland Formation and overlying strata is incorrect. The lack of any marine fossils and the autochthonous coal swamp model are the two constraints that force uniformitarian scientists to define coal layers within a non-marine setting. However, work by Austin (1979; 1986) on coal formation has clearly demonstrated a different manner in which young-earth creationists can define coal layers within the subsurface based on the Genesis Flood. Likewise, my own work on coal development reveals inconsistencies in the uniformitarian interpretation that can easily be resolved by invoking Flood-related conditions (Froede, 2004).

I am interested in better understanding the evidence that Doughty can present in defense of the Fruitland Formation coal deposits having formed within a post-Flood setting. This has important implications for defining coal deposits globally within the context of the young-earth Flood framework.

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The “Heat Problem” for Accelerated Nuclear Decay—Another Look

Gormon Gray (Gray, 2006) writes in the December 2006 issue of *CRSQ* that if there was accelerated nuclear decay during the Flood sufficient to account for currently-observed isotope ratios “the heat generated in the time frame suggested calculates to vaporize the plutons and batholiths!” This is a criticism I have heard elsewhere.

However, this criticism assumes that accelerated decay took place under nuclear force conditions identical to today’s, which doesn’t actually make sense. If there was accelerated nuclear decay, something about the forces holding nuclei together must have changed. Changing the forces holding nuclei together would change the energy released during radioactive decay, which could “vaporize” the problem.

An important concept in nuclear decay is called the “binding energy” of a nucleus. It is simply the difference between the potential energy (from all sources of potential energy) of the “bound” nucleus (i.e. the one that exists before nuclear decay) and the individual nucleons, i.e. the protons and neutrons.

A nucleus exists at all because the attractive forces holding it together (primarily the strong nuclear force) are stronger than the repulsive forces trying to split it apart (i.e. the electromagnetic force). Protons in close proximity attract one another due to the strong nuclear force, but being positively charged, they also repel one another, whereas neutrons, being uncharged, do not repel one another or protons but do contribute attraction due to the strong nuclear force. This is why heavier elements that are stable tend to have more neutrons than protons.

The strong nuclear force is extremely short in its distance of effect. The repulsive Coulomb electrostatic force is overcome by the strong nuclear force at close distances, but in large nuclei, it can nearly balance the strong force over the distance across the nucleus. Thus, if the nucleus “flexes” even a tiny amount, the repulsive force can overcome the attractive force, and nuclear decay occurs. Due to the binding energy, which is potential energy, when nuclear decay occurs, a release of energy also occurs.

Looking up “nuclear binding energy” in Wikipedia, we find the following equation for the binding energy of a nucleus.

“The binding energy for a single atom is given by equation 1

$$\Delta E = \Delta m \cdot c^2 = (m_s - m_b) \cdot c^2$$
$$= (Z \cdot m_p + N \cdot m_n - m_b) \cdot c^2 \qquad (1)$$

where

c is the speed of light;
m_s is the mass of the separated nucleons;
m_b is the mass of the bound nucleus;
Z is the atomic number of the bound nucleus;
m_p is the mass of one proton;
N is the number of neutrons;
m_n is the mass of one neutron.”

There are two interesting things to note about this equation:

- There is a strong dependence on the speed of light. This is actually a disappointment to those who suggest a drop in the speed of light over time as a way out of the “distant starlight” conundrum, as an increase in the binding energy of a nucleus implies a greater energy loss upon it’s decay, thus making accelerated decay more energetic, and
- there are hidden, all-important constants and/or exponents in the (m_s - m_b) term.

If the speed of light was faster in the past, this would be incompatible (all else being equal) with a reduction in heat during nuclear decay, thus the “heat problem” would remain, and in fact be worse.

Wikipedia also gives a semiempirical formula: “For a nucleus with A nucleons including Z protons, a semiempirical formula for the binding energy per nucleon is

$$E / A = a - b / \sqrt[3]{A} - c(Z / \sqrt[3]{A^2})^2$$
$$- d(N - Z)^2 / \sqrt[3]{A^{3+3}} \pm e / \sqrt[4]{A^{3+4}} \qquad (2)$$

[Note: this equation simplifies to]

$$E/A = a - b/A^{(1/3)} - c(Z^2/A^{(4/3)})$$
$$- d(N - Z)^2/A^2 \pm e/A^{(7/4)} \qquad (3)$$

“where the binding energy is in MeV for the following numerical values of the constants: $a = 14.0$; $b = 13.0$; $c = 0.585$; $d = 19.3$; $e = 33$.”

“The first term a is called the saturation contribution and ensures that the B.E. per nucleon is the same for all nuclei to a first approximation.”

“The term $b/A^{(1/3)}$ is a surface tension effect and is proportional to the number of nucleons that are situated on the nuclear surface. It is largest for light nuclei.

“The term $c(Z^2/A^{(4/3)})$ is the Coulomb electrostatic repulsion. This becomes more important as Z increases.”

“The symmetry correction term $d(N - Z)^2/A^2$ takes into

Table I. Calculated and Measured Binding Energies per Nucleon for Selected Nuclei (from Wikipedia).

	Formula	Measured
Al^{27}	8.42	8.33
Cu^{63}	8.75	8.75
Mo^{98}	8.62	8.63
Pt^{195}	7.87	7.92
U^{238}	7.56	7.58

account the fact that in the absence of other effects the most stable arrangement has equal numbers of protons and neutrons. This is because the n-p interaction in a nucleus is stronger than either the n-n or p-p interaction."

"The pairing term ± $e/A^{(7/4)}$ is purely empirical. It is + for even-even nuclei and – for odd-odd nuclei."

The article included the a table with the binding energy per nucleon in MeV for selected isotopes (See Table I).

It is interesting to calculate what changing the constants and/or exponents of the various terms does to the calculated binding energies per nucleon. This has been done for two nuclei, Al^{27} and U^{238}. The results are shown in Tables II–V.

Table II. Changing the Values of the Constants in Equation 3 for Al^{27} Calculated BE 8.33.

		Protons Z 13	Nucleons A 27	Neutrons N 14			
Constant	Current Term Value	Current Equation Value	10% Decrease a	10% Increase b	10% Increase c	10% Increase d	10% Increase e
a	14.000	14.000	12.600	14.000	14.000	14.000	14.000
b	13.000	-4.333	-4.333	-4.767	-4.333	-4.333	-4.333
c	0.585	-1.221	-1.221	-1.221	-1.343	-1.221	-1.221
d	19.300	-0.026	-0.026	-0.026	-0.026	-0.029	-0.026
e	33.000	-0.103	-0.103	-0.103	-0.103	-0.103	-0.114
Total BE per nucleon		8.316	6.916	7.883	8.194	8.314	8.306

Table III. Changing the Values of the Constants in Equation 3 for U^{238} Calculated BE 7.58.

		Protons Z 92	Nucleons A 238	Neutrons N 146			
Constant	Current Term Value	Current Equation Value	10% Decrease a	10% Increase b	10% Increase c	10% Increase d	10% Increase e
a	14.000	14.000	12.600	14.000	14.000	14.000	14.000
b	13.000	-2.098	-2.098	-2.308	-2.098	-2.098	-2.098
c	0.585	-3.357	-3.357	-3.357	-3.693	-3.357	-3.357
d	19.300	-0.994	-0.994	-0.994	-0.994	-1.093	-0.994
e	33.000	0.002	0.002	-0.002	-0.002	-0.002	-0.003
Total BE per nucleon		7.554	6.154	7.340	7.214	7.450	7.549

From these calculations, several observations are obvious:

- Changing the value of the saturation term a has a substantial effect on the binding energy per nucleon for both light and heavy atoms.
- Changing the value of the *b* constant does indeed affect lighter elements more than heavier ones, and has a significant effect.
- Changing the value of the exponent on the A part of the *c* (electrostatic) term has a substantial effect on lighter elements, but a massive effect on the binding energy per nucleon in heavier elements.
- Changes to the remaining terms are not large in either light or heavier elements.

Thus, a 10% change in the exponent of part of the electrostatic term would have the effect that nuclear decay of heavier elements would be increased more so than that of lighter elements, and that the heat energy released per decay would be drastically decreased. This is not to claim that this is "the answer" to the supposed "heat problem," however it

Table IV. Changing the Values of the Exponents in Equation 3 for Al^{27} Calculated BE 8.33.

		Protons Z 13	Nucleons A 27	Neutrons N 14		
Constant	**Current Term Value**	**Current Equation Value**	**10% Decrease b trm exp**	**10% Decrease c trm exp***	**10% Decrease d trm exp**	**10% Decrease e trm exp**
a	14.000	14.000	14.000	14.000	14.000	14.000
b	13.000	-4.333	-4.837	-4.333	-4.333	-4.333
c	0.585	-1.221	-1.221	-1.894	-1.221	-1.221
d	19.300	-0.026	-0.026	-0.026	-0.051	-0.026
e	33.000	0.103	-0.103	-0.103	-0.103	-0.184
Total BE per nucleon		8.523	7.813	7.643	8.292	8.236

* Reduction in A term exponent only.

Table V. Changing the Values of the Exponents in Equation 3 for U^{238} Calculated BE 7.58.

		Protons Z 92.000	Nucleons A 238	Neutrons N 146		
Constant	**Current Term Value**	**Current Equation Value**	**10% Decrease b trm exp**	**10% Decrease c trm exp***	**10% Decrease d trm exp**	**10% Decrease e trm exp**
a	14.000	14.000	14.000	14.000	14.000	14.000
b	13.000	-2.098	-2.518	-2.098	-2.098	-2.098
c	0.585	-3.357	-3.357	-6.964	-3.357	-3.357
d	19.300	-0.994	-0.994	-0.994	-1.337	-0.994
e	33.000	0.002	-0.002	-0.002	-0.002	-0.006
Total BE per nucleon		7.554	7.130	3.943	7.206	7.546

* Reduction in A term exponent only.

does point out that changes to the physical laws of nature, which could be required to accelerate nuclear decay, could accomplish both accelerated nuclear decay and reduced heat generation during the decay events. This in turn goes to show what I always maintain, which is that I never let evolutionists do my assuming for me.

Note, however, that changing the binding energy may also impact the resulting fragmentation pattern of the nuclei during decay. I have not attempted to determine if this is so, and what changes, if any would be expected.

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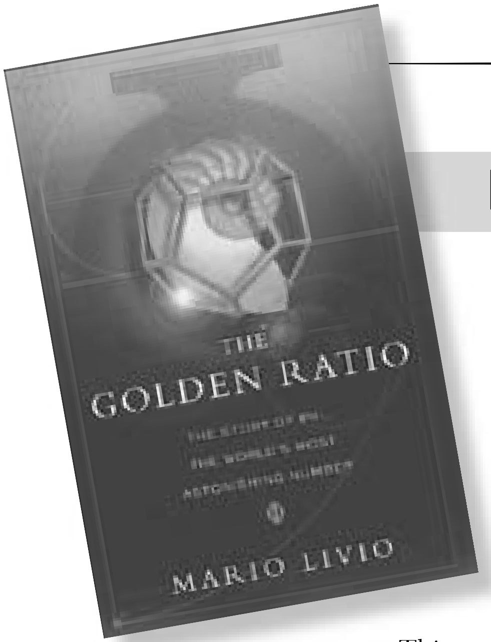

Book Review

The Golden Ratio

by Mario Livio

Broadway Books, New York, 2002, 294 pages, $25.00.

This mathematics book hit the best-seller list for several weeks. It concerns Fibonacci numbers and the related golden ratio, or mean. This is the irrational number 1.6190339887… which also is sometimes called the Divine Proportion. Author Livio is an astrophysicist who works with the Hubble Space Telescope.

The golden ratio was known in antiquity. It can be generated by taking the ratio of two adjacent larger Fibonacci numbers (1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …). Hence 89/55=1.618182, 987/610=1.618033, etc. This famous ratio occurs frequently in nature. Examples include the pattern of leaves on plant stems, a seashell's spiral, metallic crystals (p. 209), stock market trends (p. 223), and even the shape of galaxies. The Greek *Parthenon* probably was built with golden mean dimensions in mind (p. 72).

Livio writes a fascinating chapter on the origin of mathematics. Is math an arbitrary invention of the mind, or is it imbedded in nature as an independent entity waiting to be discovered? Livio accepts the former idea that our proper understanding of math has simply *evolved* to its current form because of its usefulness (p. 251). He would predict that a replay of human history would generate an entirely different form of mathematics. However, this view fails to answer two basic questions. First, why has mathematics been so successful in describing natural phenomena? Second, why does math have such excellent predictive value? Very often, new mathematical equations are studied, only to find out much later that the equations exactly describe existing parts of nature. Only the creation view of nature provides a satisfying explanation: Mathematics, including applications of the golden mean, is the precise language God employed during the Creation week.

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Submit an original plus two copies of each manuscript to the editor of the *Creation Research Society Quarterly* (see the inside front cover for address). Concurrent submission of an electronic version (Word, WordPerfect, or Rich Text Format) of the manuscript text and graphics is also encouraged. The manuscript and graphics will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. Manuscripts containing more than 30 pages are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

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Submitted manuscripts should have the following organizational format:

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3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the Society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently-used terms can be abbreviated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide gel electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms "microevolution" and "macroevolution," authors should clearly define how they are specifically using these terms. Use of the term "creationism" should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

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Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

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Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

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Creation Research Society

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2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
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